QUAIN'S ANATOMY.

QUAIN'S ANATOMY.

Charles E. S. Hughes
Mag: Hall. Oxford
1866

Seventh Edition.

EDITED BY

WILLIAM SHARPEY, M.D., F.R.S.,
PROFESSOR OF ANATOMY AND PHYSIOLOGY IN UNIVERSITY COLLEGE, LONDON.

ALLEN THOMSON, M.D., F.R.S.,
PROFESSOR OF ANATOMY IN THE UNIVERSITY OF GLASGOW.

AND

JOHN CLELAND, M.D.,
PROFESSOR OF ANATOMY IN QUEEN'S COLLEGE, GALWAY.

PART II.

CONTAINING

THE DESCRIPTIVE ANATOMY OF THE HEART, BLOODVESSELS, ABSORBENTS, BRAIN, AND NERVES, WITH A FURTHER PORTION OF THE GENERAL ANATOMY.

ILLUSTRATED BY 273 ENGRAVINGS ON WOOD.

LONDON:
WALTON AND MABERLY,
GOWER STREET, AND IVY LANE, PATERNOSTER ROW.
1866.

LONDON:
BRADBURY, EVANS, AND CO., PRINTERS, WHITEFRIARS.

exposure to air, is doubtless generally due to the presence of blood-corpuscles, and may be explained in the same way as the occasional red colour of lymph.

Like blood and lymph, both of which fluids it greatly resembles in constitution, the chyle consists of a liquid holding small particles in suspension. These particles are, 1. *Chyle corpuscles*, or chyle globules, precisely like the lymph globules and pale blood corpuscles already described. 2. *Molecules*, of almost immeasurably minute but remarkably uniform size. These abound in the fluid, and form an opaque white molecular matter diffused in it, which Mr. Gulliver has named the *molecular base* of the chyle. The addition of ether instantly dissolves this matter, and renders the chyle nearly, but not quite, transparent; whence it may be inferred that the molecules are minute particles of fatty matter, and no doubt the chief cause of the opacity and whiteness of the chyle. According to the late Prof. H. Müller, they are each coated with a fine film of albuminoid matter. They exhibit the usual tremulous movements common to the molecules of many other substances. 3. *Oil globules;* these are of various sizes, but much larger than the molecules above described, and are often found in the chyle in considerable numbers. 4. *Minute spherules* (Gulliver), from $\frac{1}{24000}$ to $\frac{1}{30000}$ of an inch in diameter; probably of an albuminous nature, and distinguished from the fatty molecules by their varying magnitude and their insolubility in ether. The *Free nuclei* described in the chyle by Kölliker he now considers to be derived from corpuscles accidentally ruptured in the examination.

The plasma, or liquid part of the chyle, contains fibrin, so that chyle coagulates on being drawn from the vessels, and nearly all the chyle corpuscles, with part of the molecular base, are involved in the clot. The serum which remains, resembles in composition the serum of lymph; the most notable difference between them being the larger proportion of fatty matter contained in the chyle-serum.

The following analyses of lymph and chyle exhibit the proportions of the different ingredients; but it must be explained that the amount of the corpuscles cannot be separately given, the greater part of them being included in the clot and reckoned as fibrin. No. 1 is the mean of two analyses, by Gubler and Quevenne, of human lymph taken during life from the lymphatics of the thigh; No. 2, the mean of three analyses by Gmelin of lymph from the thoracic duct of horses after privation of food; No. 3, by Dr. O. Rees, of chyle from the lacteals of an ass, after passing the mesenteric glands.

	I.	II.	III.
Water	937·32	939·70	902·37
Fibrin	0·595	10·60	3·70
Albumen	42·775	38·83	35·16
Fat	6·51	a little	36 01
Extractive matter	5·05 }	10·87	22·76
Salts	7·75 }		
	1000.	1000.	1000.

The extractive matters of the chyle and lymph probably vary with the nature of the food: they generally contain sugar and urea in appreciable quantities.

The chyle, when taken from the lacteal vessels before it has reached the glands, is generally found to coagulate less firmly than in a more advanced stage of its progress. In like manner the lymph, before passing the lymphatic glands, occasionally exhibits the same weak coagulation; but Mr. Lane justly remarks, that the lymph does not differ in coagulability in the different stages of its progress so

decidedly and so generally as has been sometimes alleged; and this observation accords with the statement of Mr. Hewson on the same point.

Dr. Rees has examined the fluid contained in the thoracic duct of the human subject. It was obtained from the body of a criminal an hour and a half after execution, and, from the small quantity of food taken for some hours before death, it must have consisted principally of lymph. It had a milky hue with a slight tinge of buff; part of it coagulated feebly on cooling: its specific gravity was 1024. Its analysis, compared with that of chyle from the ass, showed less water, more albumen, less aqueous extractive, and a great deal less fat.

FORMATION OF THE CORPUSCLES OF THE LYMPH AND CHYLE.

The lymph-plasma appears to consist fundamentally of blood-plasma, which, having exuded from the capillary blood-vessels and yielded nutritive material to the tissues, is, with more or less admixture of waste products, returned by the lymphatics. As to the origin of the lymph and chyle corpuscles, it may, in the first place, be observed that the greatly increased proportion of these bodies in the vessels which issue from the lymphatic glands, and the vast store of corpuscles having the same characters contained in the interior recesses of these glands, are unmistakeable indications that the glands are at least a principal seat of their production. They are, most probably, produced by division of parent corpuscles or cells contained in the glands, and in some measure also by further division of corpuscles thus produced, after they have made their way into the lymphatic vessels. The corpuscles found sparingly both in chyle and lymph before passing the mesenteric glands may be in part formed in the agminated and solitary follicular glands of the intestine—which, though differing so much in form, yet in essential structure have much in common with the lymphatic glands—and may come partly also from the irregular deposits of pale corpuscles, which have recently been recognised in the intestinal mucous membrane. Lymph-corpuscles are supposed also to be produced in the spleen, and in the thymus and thyroid glands; but corpuscles, although few in number, and not invariably present, have been found in the lymph of various regions of the body before it has reached the glands, and they are present in the lymph of cold-blooded vertebrata, whose lymphatic vessels, although forming a well developed system, do not pass through glands. It, therefore, seems necessary to admit some further source of the corpuscles; but what this may be is very much a matter of conjecture. It has been suggested that lymph corpuscles are produced by multiplication of cells in the epithelium which lines the lymphatic vessels, in the same way as mucous corpuscles are supposed to be formed from the epithelium of mucous membranes.

FORMATION OF THE BLOOD CORPUSCLES.

In the embryo of batrachians.—In the early embryo of the frog and newt (in which, perhaps, the steps of the process are best ascertained), at the time when the circulation of the blood commences, the corpuscles in that fluid appear as rounded cells, filled with granular matter, and of larger average size than the future blood corpuscles. The bodies in question, although spoken of as cells and presenting a regularly-defined outline, have no separable envelope. They contain, concealed in the midst of the granular mass, a pellucid globular nucleus, which usually presents one or two small clear specks, situated eccentrically. The granular contents consist partly of fine molecules, exhibiting the usual molecular movements; and partly of little angular plates, or tablets, of a solid substance, probably of a fatty nature. After a few days, most of the cells have assumed an oval figure, and are somewhat reduced in size; and the granular matter is greatly diminished in quantity, so that the nucleus is conspicuous. Now, also, the blood corpuscles, previously colourless, have acquired a yellowish or faintly red colour. In a further stage, the already oval cell is flattened, the granules entirely disappear, the colour is more decided, and, in short, the blood corpuscle acquires its permanent characters. From this description it will be seen that the blood-cells which first appear agree in nature with the embryonic cells (described at page xvi), and they are, in all probability, produced by the process of segmentation, which is known to take place in the frog's ovum. The different parts of the embryo in its early condition, the heart, for example, are for a time entirely composed of cells of the same kind, and all have probably a common origin.

In the bird.—In the egg of the bird, the first appearance of blood corpuscles, as well as of blood-vessels, is seen in the blastoderma, or germinal membrane, a structure formed by the extension of the cicatricula in the early stages of incubation. The commencing embryo, with its simple tubular heart, is seen in the middle of this circular membrane, and blood-vessels, containing blood corpuscles, appear over a great part of its area. These first vessels, therefore, though connected with the heart, and intended to convey nutriment to the embryo, are formed in an exterior structure; but in a somewhat later stage, blood-vessels and corpuscles are developed in various textures and organs within the body. The formation of blood corpuscles in the vascular area of the blastoderma has been sedulously investigated by various inquirers; and from their concurrent statements, we learn that these corpuscles, at a certain stage of their progress, are rounded bodies, larger than the blood-disks of the adult. They contain a granular nucleus, and are quite devoid of colour. These spheroidal colourless corpuscles in their further advancement become flattened, and assume an oval figure. While undergoing these changes of form, they acquire a red colour, which is at first faint and yellowish, but gradually deepens.

As to the earlier part of the process—the production of the above-mentioned round cells, whose subsequent conversion into coloured oval disks has just been described—it has been held that the cells which form the substance of the blastoderma and embryo partly pass directly into blood corpuscles, and partly generate the latter by fissiparous multiplication.

In man and mammalia.—In the embryo of man and mammalia the primitive blood corpuscles are round, nucleated, colourless bodies, as in the cases above described. Their substance, originally granular, speedily clears up and acquires colour, and thus they appear as nucleated red corpuscles, of spheroidal shape, and of much larger size than the future red disks. They are embryonic cells, most probably loosened from each other and set free in the excavation of the originally solid vessels in the blastoderma and embryo-body; and, both in their primitive state and after acquiring colour, they increase in number by fissiparous multiplication, as represented in fig. xi., p. xvii. These large nucleated red and colourless corpuscles, continuing to increase in number, constitute the earliest and, for a time, the only corpuscles in the embryo-vessels. But their multiplication is soon arrested, and a new epoch in blood-formation begins with the development of the liver. The blood which returns to the embryo charged with fresh material of nutrition from the maternal system, has then to pass, at first entirely, afterwards in great part, through the vessels of the liver, and it would seem that henceforth colourless nucleated corpuscles are produced in that organ and poured abundantly into the general mass of blood by the hepatic veins. It is probable that the liver continues its hæmapoietic or blood-forming function throughout fœtal life; but, in the meanwhile, the spleen and lymphatic system have also begun to produce pale corpuscles, and in after periods supersede the liver in that office. These corpuscles, either immediately or after fissiparous multiplication, acquire colour like the first—those from the liver and spleen probably in great part before they leave these organs—and are converted into nucleated red corpuscles. The nucleated red corpuscles thus produced are gradually converted into, or at least succeeded by, smaller disk-shaped red corpuscles without nuclei, having all the characters of the blood-disks of the adult. This transition or substitution begins early, and proceeds gradually, until at length, long before the end of intrauterine life, the *nucleated* red corpuscles have altogether vanished.

Throughout life the mass of blood is subject to continual change; a portion of it is constantly expended, and its place taken by a fresh supply. It is certain that the corpuscles are not exempted from this general change, but it is not known in what manner they are consumed, nor has the process been fully traced by which new ones are continually formed to supply the place of the old. With regard to the latter question, it may be stated, that the explanation which has hitherto found most favour with physiologists is, that the corpuscles of the chyle and lymph passing into the sanguiferous system, become the pale corpuscles of the blood; and that these last are converted into red disks. Pale corpuscles are also generated in the spleen, and, after part of them have changed into red disks, pass directly into the blood, independently of those derived from the chyle and lymph. As to the manner in which the pale corpuscles are transformed into the red, there is considerable difference of opinion.

According to one view (adopted by Paget, Kölliker, Funke, and others), the pale corpuscles gradually become flattened, acquire coloured contents, lose their nuclei, and shrink somewhat in size, and thus acquire the characters of the red disks. But Mr. Wharton Jones has, from an extended series of observations, arrived at the conclusion that, whilst in birds, reptiles. and fishes, the pale or lymph corpuscle, suffering merely some alteration of form and contents, becomes the red disk, its nucleus alone is developed into the red disk of mammalian blood. According to this view (supported by Busk, Huxley, and Gulliver), while the red corpuscle of oviparous vertebrata is the transformed pale corpuscle—its development not proceeding beyond this stage—the non-nucleated red disk of man and mammalia is, on the other hand, considered to be, not the homologue of the oval nucleated red disk of the oviparous vertebrata, but that of its nucleus. It is not within the scope of this work to enter upon a discussion of the relative merits of these opinions, and the reader is referred to physiological works for a consideration of these and other views adopted by various authors upon the point at issue.

EPIDERMIC, EPITHELIAL, OR CUTICULAR TISSUE.

General nature and situation.—It is well known, that when the skin is blistered, a thin, and nearly transparent membrane, named the cuticle or epidermis, is raised from its surface. In like manner, a transparent film may be raised from the lining membrane of the mouth, similar in nature to the epidermis, although it has in this situation received the name of "epithelium;" and under the latter appellation, a coating of the same kind exists on nearly all free surfaces of the body. It is true that in many situations the epithelium cannot be actually raised from the subjacent surface as a coherent membrane, still its existence as a continuous coating can be demonstrated; and, although in different parts it presents important differences, it has in all cases the same fundamental structure, and its several varieties are connected by certain common characters.

The existence of a cuticular covering in one form or other, has been demonstrated in the following situations: viz. 1. On the surface of the skin. 2. On mucous membranes; a class of membranes to be afterwards described, which line those internal cavities and passages of the body that open exteriorly, viz., the alimentary canal, the lachrymal, nasal, tympanic, respiratory, urinary, and genital passages; as well as the various glandular recesses and ducts of glands, which open into these passages or upon the surface of the skin. 3. On the inner or free surface of serous membranes, which line the walls of closed cavities in the head, chest, abdomen, and other parts. 4. On the membranes termed synovial within the joints. 5. On the inner surface of the blood-vessels and lymphatics.

Structure in general.—This tissue has no vessels, and, except in certain parts of the organs of the senses, is devoid of nerves, and of sensibility; it, nevertheless, possesses a decidedly organised structure. Wherever it may exist, it is formed essentially of nucleated cells united together by cohesive matter, often in too small quantity to be apparent. The cells, in whatever way they may be produced, make their appearance first in the deepest part of the structure, where they receive material for growth from the blood-vessels of the subjacent tissue; then, usually undergoing considerable changes in size, figure, and consistency, they gradually rise to the surface, where, as shown at least in various important examples, they are thrown off and succeeded by others from beneath. In many situations the cells form several layers, in which they may be seen in different stages of progress, from their first appearance to their final desquamation. The layer or layers thus formed, take the shape of the surface to which they are

applied, following accurately all its eminences, depressions and inequalities. Epithelium when destroyed or cast off, is, for the most part, very readily regenerated.

In accordance with the varied purposes which the epithelium is destined to fulfil, the cells of which it is composed come to differ in different situations, in figure and size, in their position in respect of each other, their degree of mutual cohesion, and in the nature of the matter they contain, as well as in the vital endowments which they manifest ; and founded on these modifications of its constituent cells, or, at any rate, those forming the superficial layer, four principal varieties of epithelium have been recognised, namely, the *scaly*, the *columnar*, the *spheroidal*, and the *ciliated*, each of which will now be described in particular.

It may first be remarked, however, that amidst these changes the nucleus of the cell undergoes little alteration, and its characters are accordingly remarkably uniform throughout. It is round or oval, and more or less flattened ; its diameter measures from $\frac{1}{6000}$th to $\frac{1}{4000}$th of an inch, or more. Its substance is insoluble in acetic acid, and colourless, or but slightly tinted. It usually contains one or two nucleoli, distinguished by their strong dark outline ; and a variable number of more faintly-marked granules irregularly scattered. For the most part, the nucleus is persistent, but in some cases it disappears from the cell.

Scaly Epithelium. — The *scaly*, *lamellar*, *tabular*, or *flattened* epithelium (comprehending, in part, the pavement or tesselated epithelium of the German anatomists). In this variety the epithelium particles have the form of small angular plates, or thin scales ; in some situations forming a single thin layer, in others accumulating in many super-imposed strata, so as to afford to the parts they cover a defensive coating of considerable strength and thickness.

Fig. XX.

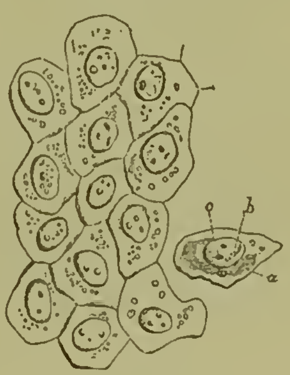


Fig. XX.—Fragment of Epithelium from a Serous Membrane (Peritoneum) ; magnified 410 diameters.

a, cell ; *b*, nucleus ; *c*, nucleoli (Henle).

As a *simple layer*, it is found on the serous, and some synovial membranes, the inner surface of the heart, blood-vessels and absorbents ; also partly lining the cerebral ventricles and covering the choroid plexuses ; on certain parts within the eye and ear, and in some gland ducts.

If the surface of the peritoneum, pleura, pericardium, or other serous membrane be gently scraped with the edge of a knife, a small quantity of soft matter will be brought away, which, when examined with the microscope, will be found to contain little shred-like fragments of epithelium, in which a few of its constituent particles still hold together, like the pieces composing a mosaic work (fig. xx.). These particles, which are flattened cells, have for the most part a polygonal figure, and are united to each other by their edges. Each has a nucleus, apparently in or near the centre. The addition of weak acetic acid renders the angular outline of the cells as well as the nucleus more distinct. The cells differ somewhat in size on different parts of the serous membrane ; and those which cover the plexus choroides send downwards short, pointed, transparent processes towards the subjacent tissue.

The epithelium of the vascular system resembles in many parts that of

the serous membranes; but in some situations, and especially in the arteries, the flattened cells, together with their nuclei, assume an oblong fusiform figure, and sometimes their outline becomes indistinct from blending of neighbouring cells.

A scaly epithelium, in which the cells form several layers, (thence named *stratified*) covers the skin, where it constitutes the scarf-skin or epidermis, which, together with the hairs and nails, will be afterwards more fully described. In this form it exists, also, on the conjunctival covering of the eyeball; on the membrane of the nose for a short distance inwardly; on the tongue and the inside of the mouth, throat and gullet; on the vulva and vagina, extending some way into the cervix of the uterus; also (in both sexes), on a very small extent of the membrane of the urethra, adjoining the external orifice. It is found, also, on the synovial membranes which line the joints. Its principal use, no doubt, is to afford a protective covering to these surfaces, which are almost all more or less exposed to friction.

Fig. XXI.

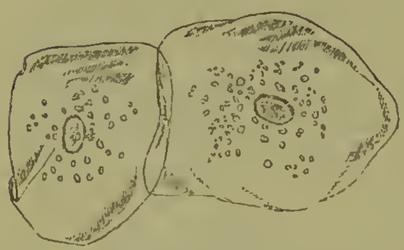


Fig. XXI.—Epithelium Scales from the inside of the Mouth; magnified 260 diameters (Henle).

The cells in this sort of epithelium become converted into broad thin scales, from $\frac{1}{850}$ to $\frac{1}{500}$ of an inch in diameter, which are loosened and cast off at the free surface. Such scales, both single and connected in little patches, may be at all times seen with the microscope in mucus scraped from the inside of the mouth, as shown in fig. xxi.; but to trace the progressive changes of the cells, they must be successively examined at different depths from the surface, and the epithelium must also be viewed in profile, or in a perpendicular section, as exhibited in fig. xxii.

The deepest cells, or those next the subjacent tissue, are sometimes

Fig. XXII.

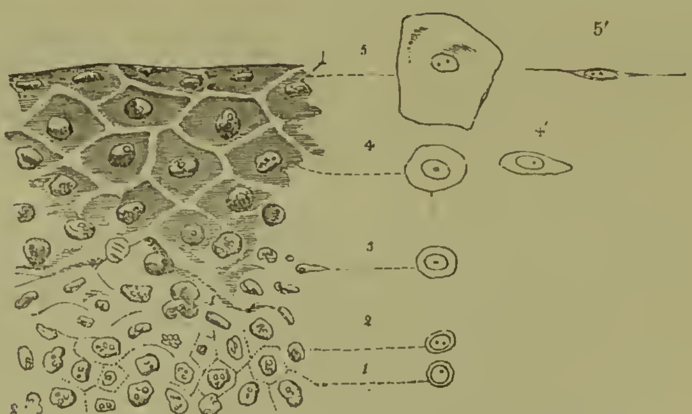


Fig. XXII.—Epithelium from the Conjunctiva of the Calf, folded so that the free surface forms the upper border of the figure, and rendered transparent by Acetic Acid.

1, 2, 3, 4, 5, progressive flattening of the cells as they rise to the surface. The outline figures represent single cells from different depths, viewed on their surface; and at 4′ and 5′, edgeways. Magnified 410 diameters (chiefly after Henle).

rounded or spheroidal in shape (fig. XXII., [1]), and but little larger than their nucleus; but more commonly the undermost layer is formed (as shown in fig. XXIII.) of oblong cells, which are placed vertically, and may be larger in size than the round cells which lie immediately over them. Such oblong vertical cells occur in the undermost layer of the epidermis, and similarly in the epithelium of the cornea and of various parts of the mucous membranes. Sometimes they form two or three successive rows. Higher up in the mass the cells are enlarged; they have a globular or oval figure, and are filled with soft matter; they next become flattened, but still retain their round or oval outline; then the continued flattening causes their opposite sides to meet and cohere, except where separated by the nucleus, and they are at length converted into thin scales, which form the uppermost layers. While they are undergoing this change of figure, their substance becomes more firm and solid, and their chemical nature is more or less altered; for the cell-membrane of the softer and more deep-seated cells may be dissolved by acetic acid, which is not the case with those nearer the surface. The nucleus at first enlarges, as well as the cell, but in a much less degree. The scales near the surface overlap a little at their edges, and their figure is very various; somewhat deeper it is mostly polygonal, and more uniform.

Fig. XXIII.

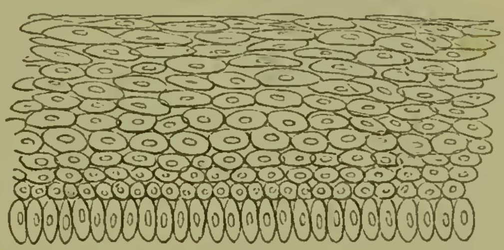


Fig. XXIII.—Diagram of Section of Epithelium, in which the undermost cells are oblong and vertical.

In various parts, the more superficial and denser layers of the scaly epithelium can be readily separated from the deeper, more recently formed, softer and more opaque part which lies underneath; so that the latter is often distinguished as the Malpighian or mucous layer (*stratum* or *rete mucosum*), although it is now well understood not to be an independent membrane. This point will be again noticed in treating of the skin.

Furrowed and spinous cells of epithelium.—It was long since noticed by Henle that the flattened cells sometimes present a striated appearance, and quite recently Max Schultze and Virchow have described cells marked on the surface with parallel ridges and furrows (*Riffzellen*), and others (*Stachelzellen*) covered with spines, and therefore presenting a fringed or denticulate border (fig. XXIV.). Both varieties have been found in the epithelium of the tongue, lips, and conjunctiva, and in the epidermis; and in all cases are confined to the deeper or Malpighian layers. Similar cells have been found in epithelial cancer and in cancroid tumours; and flattened cells, beset with minute spines on their free surface, have recently been noticed (by Brouell and Eberth) in the epithelium covering the inner surface of the cat's amnion.

In thin vertical sections of the epidermis of the fingers I have seen what appeared to be cells with a deeply serrated outline, in the Malpighian layer, but I have not been able to separate them so as to examine them singly.

Growth.—It must be admitted that the continued production of new cells by which this and other kinds of epithelium are maintained, is not yet thoroughly understood. It was at one time commonly believed that the cells which go through the changes of form and position already described, are formed from nuclei arising by independent formation in a blastema supplied by the subjacent vascular membrane; but it is now

more generally held that the new epithelium-cells are produced by division of pre-existing cells in the lowermost stratum. In the earliest condition of the embryo there are special layers of cells, derived from the primitive embryonic cells, set aside for the production of the epidermis and of the intestinal and glandular epithelium; and it is quite conceivable, and by some histologists considered most probable, that the subsequent generations of epidermic and epithelial cells by which the tissue is throughout life maintained, are derived by unbroken descent from the original embryonic stratum. At the same time the reproduction of epidermis in cicatrices after wide and deep destruction of the subjacent skin, implies some other source of new cells; unless indeed it be supposed that the new cuticle grows exclusively from the old at the circumference of the sore. Setting aside this supposition, we might conceive the new cells to come from the connective-tissue corpuscles of the granulating surface of the new-growing skin; and a recent writer (Dr. Otto Weber) describes such mode of reproduction of epidermis as actually observed by him in the healing of wounds; moreover, it may be questioned whether, in certain situations, this may not be the regular process by which the growth of epithelium is maintained.

Fig. XXIV.

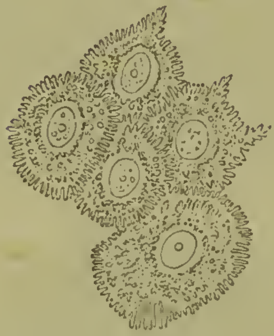


Fig. XXIV.—Spinous Cells from the Malpighian layer of the Human Epidermis; about $\frac{1}{1000}$ inch in diameter (after M. Schultze, Virch. Arch. vol. 30).

When the lowermost cells are elongated and vertical, it is difficult to conceive that they rise up as such, and take their place in the upper strata; for the cells next above them are spheroidal in shape and smaller in size. It seems more likely that they divide into or produce the smaller cells. It might be supposed that an oblong vertical cell, by division of its nucleus and separation of the upper portion of the cell-body, produces a new and smaller cell, which rises up, while the parent cell maintains its place, and lengthens out again for a repetition of the process. Dr. Schneider * describes appearances actually observed by him in the epithelium covering the front of the cornea, which seem to indicate a process of this kind; but much more extended observations are required to settle the point. I have seen cells with double or divided nuclei in the epithelium of the bladder, but not confined to the deep strata; on the other hand, I have never been able to perceive indications of division in the deep vertical cells of the epidermis; at the same time it is plain that the latter are not mere nuclei imbedded in a blastema;—the nucleus is surrounded by a tolerably well-marked cell-body, which has a deeply denticulate or fringed border at the part turned towards the corium.

Fig. XXV.

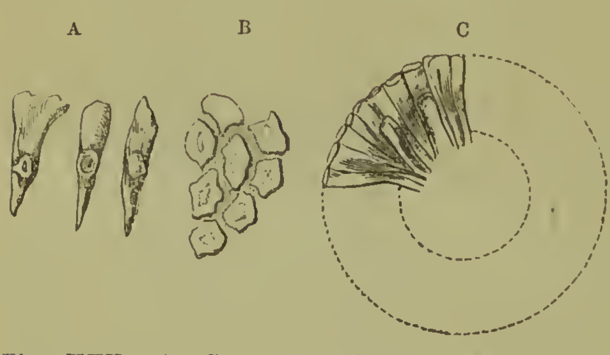


Fig. XXV.—A, Columns of Epithelium from the Intestine magnified; B, viewed by their broad free extremity; C, seen in a transverse section of an Intestinal Villus (from Henle).

Columnar Epithelium (Cylinderepithelium of Germ. Anat.).—In this variety (figs. xxv. and xxvi.), the constituent cells are elongated in a direction perpendicular to the surface of the membrane, so as to form short upright columns, which may be of the same thickness

* Würzb. Naturwiss: Zeitschrift, vol. iii. 1862.

throughout, but are, more frequently, smaller or even pointed at their lower or attached extremity, and broader at the upper (fig. XXV. A). They are mostly flattened on their sides, by which they are in mutual apposition, at least in their upper and broaded part, and have, therefore, so far a prismatic figure, their broad flat ends appearing at the surface of the epithelium in form of little polygonal areas (fig. XXV. B). The nucleus, usually oval, and containing a nucleolus, is placed near the middle of the column, and is often so large in proportion to the cell, as to cause a bulging at that part ; in which case the height of the nucleus differs in contiguous columns, the better to allow of mutual adaptation.

This variety of epithelium is confined to mucous membranes. It is found in the stomach ; on the mucous membrane of the intestines in its whole extent ; in the whole length of the urethra, except a small part at the orifice. It extends along the ducts of the greater number of glands, whether large or small, which open on the mucous membrane, but not through their entire length ; for, at their extremities, these ducts have for the most part an epithelium of a different character. It covers also the inner membrane of the gall-bladder.

Fig. XXVI.

Fig. XXVI. — Epithelium from intestinal villus of a Rabbit ; magnified 300 diameters.

a, Thick border (from Kölliker).

In these different situations the cells form but a single layer. On the proper olfactory region of the nasal mucous membrane there is a modification of the columnar epithelium, in which the cells, tinged with brownish yellow pigment, are associated with the terminations of the olfactory nerves, and present other peculiarities, which will be noticed in the special description of the organ of smelling.

The substance ordinarily contained in the columnar cells has a faintly granular aspect, and consists chiefly of mucus, which is no doubt produced in the cell. Under exposure to water this mucus swells up and escapes in form of a pellucid drop (fig. XXVII., *a*, *b*). During digestion of food containing oil or fat, the cells of the intestinal epithelium are often found to be filled with minute fat-molecules; as if they had some part to perform in the absorption of that aliment. The wall of the cell forming the basis or free end is comparatively thick (fig. XXVI., *a*), and is marked by fine parallel lines running perpendicular to the surface (fig. XXVII., 1, 2). The thick, striated border is superadded, as it were, to the thin proper wall forming the base of the cell, and is regarded by Kölliker, who first pointed out its striated character, as an excreted product of the cell, deposited upon its outer surface, as occurs in the cuticular structures of many of the inferior animals. As to the striation, it might no doubt be produced by a fine columnar or fibrous structure, but most observers agree with Kölliker in ascribing it to fine tubular passages perforating the cell-wall; and it is further supposed that such porous structure would account for the assumption of fat-molecules or other minutely divided matters into the cell, and may be subservient to an absorptive function in cells so constituted. It must be stated, however, that a thickened striated border has been since observed in various other epithelium cells which are not so obviously connected with the function of absorption, such as those lining the biliary and urinary passages, and the parotid and pancreatic ducts.

As fat, in a state of minute division, is undoubtedly taken into the epithelium cells of the intestinal villi and disappears from them again, it was natural to look for some

way by which it might be conveyed from the cells into the lacteal vessels; but hitherto the search has not been successful. The alleged communication of the cells in question with lacteal vessels, through the intermedium of connective-tissue corpuscles, rests on no sufficient evidence. It is true that processes, like roots, have in some cases been observed running down from columnar cells into the subjacent tissue, and in the epithelium of the olfactory membrane these radical processes are long and ramified; but the connection of these prolongations with connective-tissue corpuscles is as yet a matter of presumption only; although there is proof of such connection in the case of some ciliated epithelium cells; and it is material to observe that the *intestinal* epithelium, when examined fresh and without the aid of condensing reagents, shows no such processes.

Fig. XXVII.

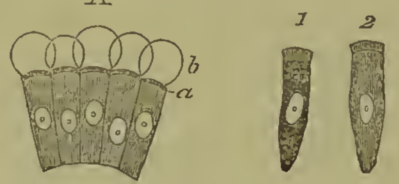


Fig. XXVII.—Cells of Intestinal Epithelium of Rabbit, treated with water; magnified 350 diameters.

1 and 2 show striated or porous border, somewhat swollen by imbibition; *a*, *b*, pellucid drops of mucus which have escaped from the cells (from Kölliker).

The particles of columnar epithelium are undoubtedly subject to shedding and renovation; but although various suppositions have been hazarded as to the mode in which this is effected, it must be admitted that no satisfactory account has been given of the process. According to Donders and Kölliker, the columnar cells on the villi appear occasionally to cast off a part from their upper end, with subsequent reparation of the loss. That is, a cell enlarges and a second nucleus appears; the upper and broader part, with one nucleus and much of the cell contents, separates, and the lower remaining portion, with its nucleus, grows again to the natural size. The extruded portion is supposed to become a mucus-corpuscle.

Spheroidal Epithelium.—In this variety, the cells for the most part retain their primitive roundness, or, being flattened where they touch, acquire a polyhedral figure, in which no one dimension remarkably predominates. Hence the above term was applied to this form of epithelium by Mr. Bowman. But in some places the cells show a tendency to lengthen into columns and in others to flatten into tables, especially when this epithelium approaches the confines of one or other of the preceding varieties; in such cases it has been named *transitional;* moreover, when the scaly and columnar varieties border upon one another, the figure of their particles is gradually changed, presenting various intermediate forms; in other words, the epithelium there puts on the transitional character, though it may be only for a very small space.

Fig. XXVIII.

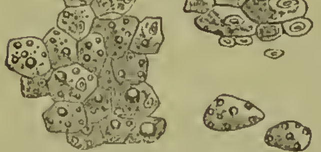


Fig. XXVIII.—Cells from the Liver magnified (Dr. Baly).

The spheroidal epithelium is found in the excretory ducts of the mammary, perspiratory, and of many mucous glands, and a modification of the spheroidal epithelium lines the inmost secreting cavities, or commencing ducts of glands generally (fig. xxviii.). In this last-mentioned situation, where it is sometimes distinguished by the name of *glandular epithelium*, the nucleated cells contain a large proportion of fine granular matter; in some cases even, the peculiar ingredients of the secretion may be recognised in them; and it is conceived, that they have a considerable share in preparing or separating these matters from the blood.

Ciliated Epithelium.—In this form of epithelium, the particles, which are

generally columnar, bear at their free extremities little hair-like processes, which are agitated incessantly during life, and for some time after death, with a lashing or vibrating motion. These minute and delicate moving organs are named *cilia*. They have now been discovered to exist very extensively throughout the animal kingdom; and the movements they produce are subservient to very varied purposes in the animal economy.

In the human body the ciliated epithelium occurs in the following parts, viz.:—1. On the mucous membrane of the air passages and its prolongations. It commences at a little distance within the nostrils, covers the membrane of the nose and of the adjoining bony sinuses, extends up into the nasal duct and lachrymal sac. From the nose it spreads backwards a certain way on the upper surface of the soft palate, and over the upper or nasal region of the pharynx; thence along the Eustachian tube and lining membrane of the tympanum, of which it covers the greater part. The lower part of the pharynx is covered by scaly epithelium as already mentioned; but the ciliated epithelium begins again in the larynx a little above the glottis, and continues throughout the trachea and the bronchial tubes in the lungs to their smallest ramifications. 2. On the mucous lining of the uterus, commencing at the middle of the cervix and extending along the Fallopian tubes, even to the peritoneal surface of the latter at their fimbriated extremities. 3. Lining the *vasa efferentia*, *coni vasculosi*, and first part of the excretory duct of the testicle. 4. To a large extent on the parietes of the ventricles of the brain, and throughout the central canal of the spinal cord.

In other mammiferous animals, as far as examined, cilia have been found in nearly the same parts. To see them in motion a portion of ciliated mucous membrane may be taken from the body of a recently killed quadruped. The piece of membrane is to be folded with its free or ciliated surface outwards, placed on a slip of glass, with a little weak salt water or serum of blood, and covered with a bit of thin glass or mica. When it is now viewed with a magnifying power of 200 diameters, or upwards, a very obvious agitation will be perceived on the edge of the fold, and this appearance is caused by the moving cilia with which the surface of the membrane is covered. Being set close together, and moving simultaneously or in quick succession, the cilia, when in brisk action, give rise to the appearance of a bright transparent fringe along the fold of the membrane, agitated by such a rapid and incessant motion, that the single threads which compose it cannot be perceived. The motion here meant, is that of the cilia themselves; but they also set in motion the adjoining fluid, driving it along the ciliated surface, as is indicated by the agitation of any little particles that may accidentally float in it. The fact of the conveyance of fluids and other matters along the ciliated surface, as well as the direction in which they are impelled, may also be made manifest by immersing the membrane in fluid, and dropping on it some finely pulverised substance (such as charcoal in fine powder), which will be slowly but steadily carried along in a constant and determinate direction; and this may be seen with the naked eye, or with the aid of a lens of low power.

The ciliary motion of the human mucous membrane is beautifully seen on the surface of recently extracted nasal polypi; and single ciliated particles, with their cilia still in motion, are sometimes separated accidentally from mucous surfaces in the living body, and may be discovered in the discharged mucus; or they may even be purposely detached by gentle abrasion.

But the extent and limits of the ciliated epithelium of the human body have been determined chiefly from its anatomical characters.

Cilia have now been shown to exist in almost every class of animals, from the highest to the lowest. The immediate purpose which they serve is, to impel matter, generally more or less fluid, along the surfaces on which they are attached ; or, to propel through a liquid medium the ciliated bodies of minute animals, or other small objects on the surface of which cilia are present ; as is the case with many infusorial animalcules, in which the cilia serve as organs of locomotion like the fins of larger aquatic animals, and as happens, too, in the ova of many vertebrate as well as invertebrate animals, where the yelk revolves in its surrounding fluid by the aid of cilia on its surface. In many of the lower tribes of aquatic animals, the cilia acquire a high degree of importance : producing the flow of water over the surface of their organs of respiration, indispensable to the exercise of that function ; enabling the animals to seize their prey, or to swallow their food, and performing various other offices of greater or less importance in their economy. In man, and the warm-blooded animals, their use is apparently to impel secreted fluids or other matters along the ciliated surface, as, for example, the mucus of the windpipe and nasal sinuses, which they carry towards the outlet of these cavities.

Fig. XXIX.

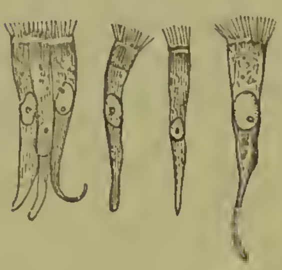


Fig. XXIX. — Columnar Ciliated Epithelium Cells from the Human Nasal Membrane ; magnified 300 diameters.

The cells of the ciliated epithelium contain nuclei, as usual ; they have most generally an elongated or prismatic form (fig. xxix.), like the particles of the columnar epithelium, which they resemble too in arrangement but are often of greater length and more slender and pointed at their lower end. The cilia are attached to their broad or superficial end, each columnar particle bearing a tuft of these minute hair-like processes. In some cases, the cells are spheroidal in figure, the cilia being still, of course, confined to that portion of the cell which forms part of the general surface of the epithelial layer, as shown in fig. xxx., which represents such cells from the epithelium of the frog's mouth. In man this form occurs in the ciliated epithelium of the cerebral ventricles and tympanum, where the cells form but a single stratum. The columnar ciliated epithelium also may exist as a simple layer, as in the uterus and Fallopian tubes, the finest ramifications of the bronchia, and the central canal of the spinal cord ; but in various other parts—as the nose, pharynx, Eustachian tube, the trachea and its larger divisions—there is a layer of elongated cells beneath the superficial ciliated range, filling up the spaces between the pointed extremities of the latter, and beneath this is an undermost layer formed of small rounded cells (fig. xxxi.). Probably the subjacent cells acquire cilia, and take the place of ciliated cells which are cast off ; but the mode of renovation of ciliated epithelium is not yet fully understood.

Fig. XXX.

Fig. XXX.—Spheroidal Ciliated Cells from the Mouth of the Frog ; magnified 300 diameters.

The relation of the ciliated, as well as other epithelium cells, to the connective-tissue

of the subjacent membrane, has much engaged attention since the importance of the connective-tissue corpuscles has come to be recognised; and a strong impression or belief prevails that such epithelium cells are structurally connected by prolongations from their lower ends with these corpuscles, and genetically related to them. As a matter of observation such anatomical connection is affirmed on excellent authority (Lockhart Clarke, Gerlach and others) in reference to the columnar ciliated epithelium of the central canal of the spinal cord and the Sylvian aqueduct, but the evidence in other cases is not so satisfactory.

Fig. XXXI.

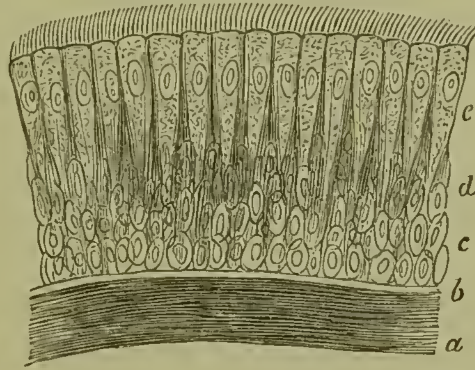


Fig. XXXI.—Ciliated Epithelium from the Human Windpipe; magnified 350 diameters.

a, *b*, subjacent membrane; *c*, lowermost or round cells; *d*, middle layer of oval cells; *c*, superficial or ciliated cells (from Kölliker).

The cilia themselves differ widely in size in different animals, and they are not equal in all parts of the same animal. In the human windpipe they measure $\frac{1}{4000}$th to $\frac{1}{2500}$th of an inch in length; but in many invertebrate animals, especially such as live in salt water, they are a great deal larger. In figure they have the aspect of slender, conical, or slightly flattened filaments; broader at the base and usually pointed at their free extremity. Their substance is transparent, soft, and flexible. It is to all appearance homogeneous, and no fibres, granules, or other indications of definite internal structure, have been satisfactorily demonstrated in it.

Motion of the cilia.—The manner in which the cilia move, is best seen when they are not acting very briskly. Most generally they seem to execute a sort of fanning or lashing movement; and when a number of them perform this motion in regular succession, as is generally the case, they give rise to the appearance of a series of waves travelling along the range of cilia, like the waves caused by the wind in a field of corn. When they are in very rapid action the undulation is less obvious, and, as Henle remarks, their motion then conveys the idea of swiftly running water. The undulating movement may be beautifully seen on the gills of a mussel, and on the arms of many polypes. The undulations, with some exceptions, seem always to travel in the same direction on the same parts. The impulsion, also, which the cilia communicate to the fluids or other matters in contact with them, maintains a constant direction; unless in certain of the infusoria, in which the motion is often variable and arbitrary in direction, and has even been supposed to be voluntary. Thus in the windpipe of mammalia, the mucus is conveyed upwards towards the larynx, and if a portion of the membrane be detached, matters will still be conveyed along the surface of the separated fragment in the same direction relatively to that surface, as before its separation.

The persistence of the ciliary motion for some time after death, and the regularity with which it goes on in parts separated from the rest of the body, sufficiently prove that, with the possible exceptions alluded to, it is not under the influence of the will of the animal nor dependent for its production on the nervous centres, and it does not appear to be influenced in any

way by stimulation or sudden destruction of these centres. The time which it continues after death or separation differs in different kinds of animals, and is also materially influenced by temperature and by the nature of the fluid in contact with the surface. In warm-blooded animals the period varies from two or three hours to two days, or even more ; being longer in summer than in the cold of winter. In frogs the motion may continue four or five days after the destruction of the brain ; and it has been seen in the gullet of the tortoise fifteen days after decapitation, continuing seven days after the muscles had ceased to be irritable.

With the view of throwing further light on the nature of this remarkable kind of motion, experiments have been made to ascertain the effect produced on it by different physical chemical and medicinal agents ; but, so far as these experiments have gone, it would seem that, with the exception of moderate heat and cold, alkaline solutions, chloroform vapour, and perhaps some other narcotics, these agents affect the action of the cilia only in so far as they act destructively on their tissue.

The effect of change of temperature is different in warm and cold-blooded animals. In the former the motion is stopped by a cold of 43° F., whereas in the frog and river mussel it goes on unimpaired at 32° F. E. H. Weber has made the interesting observation that in ciliated epithelium particles detached from the human nasal membrane, the motion which has become languid or quiescent from the cold, may be revived by warmth, such as that of the breath, and this several times in succession. A moderately elevated temperature, say 100° F., does not affect the motion in cold-blooded animals; but, of course, a heat considerably higher than this, and such as to alter the tissue, would put an end to it in all cases. Electric shocks, unless they cause abrasion of the ciliated surface (which is sometimes the case), produce no visible effect; and the same is true of galvanic currents. Fresh water, I find, arrests the motion in marine mollusca and in other salt-water animals in which I have tried its effect; but it evidently acts by destroying both the form and substance of the cilia, which in these cases are adapted to a different medium. Most of the common acid and saline solutions, when concentrated, arrest the action of the cilia instantaneously in all animals; but dilution delays this effect, and when carried farther, prevents it altogether; and hence it is, probably, due to a chemical alteration of the tissue. Virchow has observed that a solution of either potash or soda will revive the movement of cilia after it has ceased. Narcotic substances, such as hydrocyanic acid, salts of morphia and strychnia, opium and belladonna, are said by Purkinje and Valentin to have no effect, though the first-named agent has certainly appeared to me to arrest the motion in the river-mussel. In confirmation of an observation of Professor Lister,* I find that exposure for a few moments to the vapour of chloroform arrests ciliary action, and that the motion revives again if the application of the vapour is discontinued.

Bile stops the action of the cilia, while blood prolongs it, in vertebrated animals; but the blood or serum of the vertebrata has quite an opposite effect on the cilia of invertebrate animals, arresting their motion almost instantaneously.

It must be confessed that the nature and source of the power by which the cilia act are as yet unknown ; but whatever doubt may hang over this question, it is plain that each ciliated cell is individually endowed with the faculty of producing motion, and that it possesses in itself whatever organic apparatus and whatever physical or vital property may be necessary for that end ; for single epithelium cells are seen to exhibit the phenomenon long after they have been completely insulated.

Without professing to offer a satisfactory solution of a question beset with so much difficulty, it seems, nevertheless, not unreasonable to consider the ciliary motion as

* Phil. Trans. 1858, p. 690, where will be found other valuable observations on the effect of external agents on ciliary action.

being probably a manifestation of that property on which the more conspicuous motions of animals are known to depend, namely, vital contractility; and this view has at least the advantage of referring the phenomenon to the operation of a vital property already recognised as a source of moving power in the animal body. But, assuming this view to be sound, so far as regards the nature of the motile property brought into play, it affords no explanation of the cause by which the contractility is excited and the cilia maintained in constant action.

It is true that nothing resembling a muscular apparatus in the ordinary sense of the term, has been shown to be connected with the cilia, nor is it necessary to suppose the existence of any such; for it must be remembered that while the organic substance on which vital contractility depends is probably uniformly the same in composition, it does not everywhere assume the same form and texture. The anatomical characters of human voluntary muscle differ widely from those of most involuntary muscular structures, and still more from the contractile tissues of some of the lowest invertebrate animals, although the movements must in all these cases be referred to the same principle. The heart of the embryo beats while yet but a mass of cells, united, to all appearance, by amorphous matter, in which no fibres are seen; yet no one would doubt that its motions depend then on the same property as at a later period, when its structure is fully developed.

In its persistence after systemic death and in parts separated from the rest of the body, the ciliary motion agrees with the motion of certain muscular organs, as the heart, for example; and the agreement extends even to the regular or rhythmic character of the motion in these circumstances. It is true, the one endures much longer than the other; but the difference appears to be one only of degree, for differences of the same kind are known to prevail among muscles themselves. No one, for instance, doubts that the auricle of the heart is muscular, because it beats longer after death than the ventricle; nor, because a frog's heart continues to act a much longer time than a quadruped's, is it inferred that its motion depends on a power of a different nature. And the view here taken of the nature of the ciliary motion derives strength from the consideration that the phenomenon lasts longest in cold-blooded animals, in which vital contractility also is of longest endurance. In the effects of heat and cold, as far as observed, there is also an agreement between the movement of cilia and that of muscular parts; while, on the other hand, it must be allowed that electricity does not appear to excite their activity. The effects of narcotics afford little room for inference, seeing that our knowledge of their local action on muscular irritability is by no means exact; but in one instance, at least, an agent, chloroform vapour, which stops the action of the freshly excised heart of a frog, arrests also the ciliary motion. Something, moreover, may depend on the facility or difficulty with which the tissues permit the narcotic fluid to penetrate, which circumstance must needs affect the rapidity and extent of its operation. Again, we see differences in the mode in which the cilia themselves are affected by the same agent; thus fresh water instantly arrests their motion in certain cases, while it has no such effect in others.

The discovery of vibrating cilia on the spores and other parts of certain cryptogamic vegetables may perhaps be deemed a strong argument on the opposite side; but it is by no means proved that the sensible motions of plants (such, at least, as are not purely physical), and those of animals, do not depend on one common vital property.

PIGMENT.

The cells of the cuticle, and of other textures which more or less resemble it in structure, sometimes contain a black or brown matter, which gives a dark colour to the parts over which the cells are spread. A well-marked example of such pigment-cells in the human body is afforded by the black coating which lines the choroid membrane of the eye and covers the posterior surface of the iris. They are found in the epidermis of the Negro and other dark races of mankind, and in the more dusky parts of the

cuticle of the European. In different forms also they exist on certain parts of the investing membrane (pia mater) of the spinal cord, in the membranous labyrinth of the ear, and (with brownish yellow pigment) on the olfactory region of the nose.

The pigment cells of the choroid membrane (fig. XXXII.) are for the most part polyhedral in figure, most generally six-sided, and connected together like the pieces of a mosaic pavement; others are spheroidal, and most of those on the back of the iris are of that shape. The cells contain the pigment, strictly so called, which consists of black or brown granules or molecules of a round or oblong shape, and almost too small for exact measurement. These molecules are densely packed together in some cells; in others they are more scattered, and then it may be seen that there is a certain amount of colourless matter included along with them. When they escape from the ruptured cells, they exhibit very strikingly the molecular movement; and in consequence of this movement the apparent figure of the particles is subject to change. It is worthy of remark, that when viewed singly with a very high magnifying power they look transparent and almost colourless, and it is only when they are heaped together that their blackness distinctly appears. The cells have a colourless nucleus, which is very generally hidden from view by the black particles. It contains a central nucleolus.

Fig. XXXII.

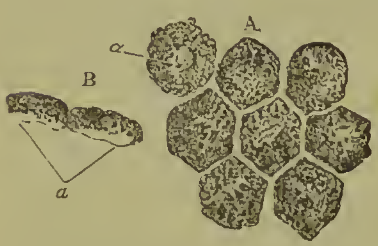


Fig. XXXII.—Pigment-Cells from the Choroid; magnified 370 diameters (Henle).

A, cells still cohering, seen on their surface; *a*, nucleus indistinctly seen. In the other cells the nucleus is concealed by the pigment granules.

B, two cells seen in profile; *a*, the outer or posterior part containing scarcely any pigment.

Examined chemically, the black matter is found to be insoluble in cold and hot water, alcohol, ether, fixed and volatile oils, acetic and diluted mineral acids. Its colour is discharged by chlorine. The pigment of the bullock's eye, when purified by boiling in alcohol and ether, was found by Scherer to consist of 58·672 carbon, 5·962 hydrogen, 13·768 nitrogen, and 21·598 oxygen; its proportion of carbon is thus very large. Preceding chemists had obtained from its ashes oxide of iron, chloride of sodium, lime, and phosphate of lime.

The dark colour of the Negro is known to have its seat in the cuticle, and chiefly in the deeper and softer part named the rete mucosum. It is caused by cells containing dark-brown colouring matter, either diffused through their substance or in form of granules—usually more densely aggregated round the nucleus. These cells are found along with ordinary, colourless cells, which in other respects they entirely resemble: and the depth of tint depends on the proportion of each. It is affirmed, on good authority, that the nuclei of these epidermic pigment-cells are coloured, but of this I have not been able to satisfy myself in examinations of the Negro skin. The dark parts of the European skin owe their colour and its different shades to intermixture in the cuticle of similar cells in different proportions. Lastly, it cannot be doubted, that in both the coloured and white races, the colouring matter of the skin is the same in its essential nature as that of the choroid. In Albino individuals, both Negro and European,

in whom the black matter of the choroid is wanting, the cuticle and the hair are colourless also.

In some situations the pigment-cells become irregular and jagged at their edges, or even branch out into long irregular processes. Such ramified cells are very common in many animals. In the human body pigment-cells of this description are found in the dark tissue on the outer surface of the choroid coat, *lamina fusca* (fig. XXXIII., *a a*), and on the pia mater covering the upper part of the spinal cord. The condition of the pigment in the hairs will be afterwards described.

When the cuticle of the Negro is removed by means of a blister, it is renewed again of its original dark hue; but if the skin be destroyed to any considerable depth, as by a severe burn, the resulting scar remains long white, though it at length acquires a dark colour.

Fig. XXXIII.

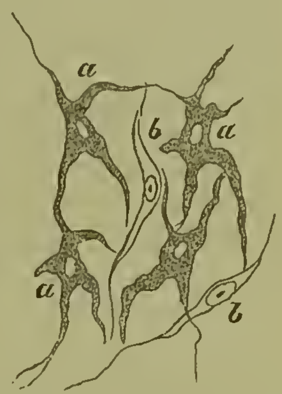


Fig. XXXIII.—Ramified Pigment Cells, from the tissue of the Choroid Coat of the Eye; magnified 350 diameters (after Kölliker).

a, cells with pigment; *b*, colourless fusiform cells.

Uses.—In the eye the black matter seems obviously intended to absorb redundant light, and accordingly its absence in Albinos is attended with a difficulty of bearing a light of considerable brightness. Its uses in other situations are not so apparent. The pigment of the cuticle, it has been supposed, may screen the subjacent cutis from the pungency of the sun's rays, but in many animals the pigment is not only employed to variegate the surface of the body, but attaches itself to deep-seated parts. Thus, in the frog the branches and twigs of the blood-vessels are speckled over with it, and in many fish it imparts a black colour to the peritoneum and other internal membranes.

ADIPOSE TISSUE.

The human body in the healthy state contains a considerable amount of fatty matter of different kinds. Fat, as has been already stated, is found in the blood and chyle, and in the lymph, but much more sparingly. It exists, too, in several of the secretions, in some constituting the chief ingredient; and in one or other of its modifications it enters into the composition of certain solid textures. But by far the greater part of the fat of the body is inclosed in small cells or vesicles, which, together with their contained matter, constitute the adipose tissue.

This tissue is not confined to any one region or organ, but exists very generally throughout the body, accompanying the still more widely distributed cellular or areolar tissue in most though not in all parts in which the latter is found. Still its distribution is not uniform, and there are certain situations in which it is collected more abundantly. It forms a considerable layer underneath the skin, and, together with the subcutaneous areolar tissue in which it is lodged, constitutes in this situation what has been called the *panniculus adiposus*. It is collected in large quantity round certain internal parts, especially the kidneys. It is seen filling up the furrows on the surface of the heart, and imbedding the vessels of that organ underneath its serous covering; and in various other situations it is depo-

sited beneath the serous membranes, or is collected between their folds, as in the mesentery and omentum, at first generally gathering along the course of the blood-vessels, and at length accumulating very copiously. Collections of fat are also common round the joints, lying on the outer surface of the synovial membrane, and filling up inequalities; in many cases, lodged, like the fat of the omentum, in folds of the membrane, which project into the articular cavity. Lastly, the fat exists in large quantity within the bones, where it forms the marrow. On the other hand there are some parts in which fat is never found in the healthy condition of the body. Thus it does not exist in the subcutaneous areolar tissue of the eyelids and penis, nor in the lungs, nor within the cavity of the cranium.

Fig. XXXIV.

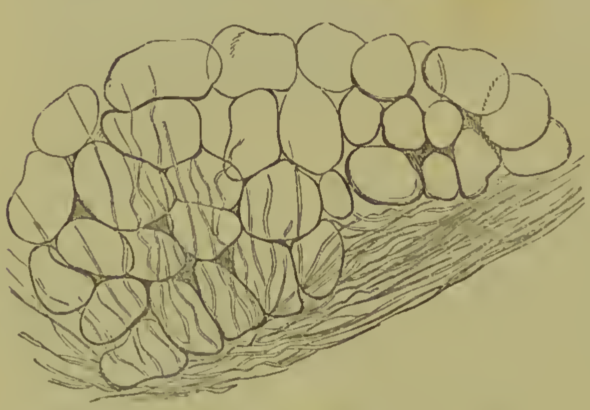


Fig. XXXIV.—A small cluster of Fat-Cells; magnified 150 diameters.

When subjected to the microscope, the adipose tissue (fig. xxxiv.) is seen to consist of small vesicles, filled with an oily matter, and for the most part lodged in the meshes of the areolar tissue. The vesicles are most commonly collected into little lobular clusters, and these again into the little lumps of fat which we see with the naked eye, and which in some parts are aggregated into round or irregular masses of considerable magnitude. Sometimes the vesicles, though grouped together, have less of a clustered arrangement; as when they collect alongside of the minute blood-vessels of thin membranous parts.

In well-nourished bodies the vesicles or fat-cells are round or oval, unless where packed closely together, in which case they acquire an angular figure, and bear a striking resemblance to the cells of vegetable tissues. The greater number of them are from $\frac{1}{300}$th to $\frac{1}{600}$th of an inch in diameter, but many exceed or fall short of this measurement. Each one consists of a very delicate envelope, inclosing the oily matter, which, completely filling the envelope, appears as a single drop. The envelope is generally quite transparent, and apparently homogeneous in structure. In ill-nourished bodies, and especially in those presenting serous infiltration of the tissues (as in dropsy), different forms of fat-cells are observed. (1.) Granular, yellowish-white vesicles, containing numerous small fat globules. (2.) Yellow, or yellowish-red cells, filled with serum and globules of brownish-yellow fat. The relative proportion of the serum and fat varies; but in all cases of this description Kölliker states that he has discovered a nucleus and nucleolus. The nucleus may be seen without re-agents, but is rendered more apparent by acetic acid. The vesicular envelope is found in different conditions. Sometimes it is normal; but it has been seen finer and also thicker than usual. When thickened it may present the appearance of either a single or a double contour. (3.) Fatless cells, with normal or thickened walls. (4.) Fat-cells containing crystals (probably of margaric acid), either yellow or white in colour. At first sight these cells appear filled

with opaque and granular contents, but upon minute examination are seen to contain stelliform acicular crystals, though in some cases their aspect is very faintly granular. It is not improbable that the crystals are formed after death.

Schwann discovered a nucleus in the fat-cells of the embryo ; the nucleus contains one or two nucleoli, and is attached to the inside of the cell-wall or imbedded in its substance. Although nuclei have rarely been seen in the cells of well-nourished adipose tissue in after-life, they are readily found when the fat has partially disappeared, and hence it may be inferred that they are always present. This is corroborated by an observation of Bruch, that the endosmose of water always renders a nucleus apparent.

The common fat of the human body has been represented as a mixture of a solid fatty substance named "margarin," and a liquid oily substance, "olein ;" the suet or fat of oxen and sheep, on the other hand, consisting chiefly of a second solid principle, "stearin," associated with olein. These substances, margarin, olein, and stearin, are neutral bodies, and themselves compounded of a base named "glycerine" with three fatty acids respectively, the margaric, oleic, and stearic.

To the above reckoned neutral fats of the animal body a fourth, namely, "palmitin," has now been added ; and they are all considered to be compounds of three equivalents of acid,—oleic, margaric, stearic, or palmitic,—with one equivalent of glycerine, minus six equivalents of water. They have accordingly been named, "triolein," "trimargarin," "tristearin," and "tripalmitin." The triolein, or liquid fat, holds the other three in solution ; and the varying consistency of animal fats depends on the relative proportion of the solid and liquid ingredients.

During life the oily matter contained in the cells is liquid ; but the acicular crystalline spots which are sometimes seen after death indicate a partial solidification of one of its constituents. This has been supposed to be the margarin ; but it appears from its chemical relations to be most probably margaric acid.

The fat being thus contained in closed cells, it will be readily understood why, though liquid or nearly so in the living body, it does not shift its place in obedience to pressure or gravitation, as happens with the water of dropsy and other fluids effused into the interstices of the areolar tissue ; such fluids, being unconfined, of course readily pass from one place to another through the open meshes.

The areolar tissue connects and surrounds the larger lumps of fat, but forms no special envelope to the smaller clusters ; and although fine fasciculi and filaments of that tissue pass irregularly over and through the clusters, yet it is probable that the vesicles are held together in these groups mainly by the fine network of capillary vessels distributed to them. In the marrow the connective tissue is very scanty ; indeed the fat-cells in some parts of the bones are said to be altogether unaccompanied by connective filaments.

The adipose tissue is copiously supplied with blood-vessels. The larger branches of these pass into the fat lumps, where they run between the lobules and subdivide, till at length a little artery and vein are sent to each small lobule, dividing into a network of capillary vessels, which not only surrounds the cluster externally, but passes through between the vesicles in all directions, supporting and connecting them. The lymphatics of the fat, if it really possess any, are unknown. Nor have nerves been seen to terminate in it, though nerves destined for other textures may pass through it.

Accordingly it has been observed that, unless when such traversing nervous twigs happen to be encountered, a puncturing instrument may be carried through the adipose tissue without occasioning pain.

As to the uses of the fatty tissue, it may be observed, in the first place, that it serves the merely mechanical purpose of a light, soft, and elastic packing material to fill vacuities in the body. Being thus deposited between and around different organs, it affords them support, facilitates motion, and protects them from the injurious effects of pressure. In this way, too, it gives to the exterior of the body its smooth, rounded contour. Further, being a bad conductor of heat, the subcutaneous fat must so far serve as a means of retaining the warmth of the body, especially in warm-blooded creatures exposed to great external cold, as the whale and other cetaceous animals, in which it forms a very thick stratum, and must prove a much more effectual protection than a covering of fur in a watery element.

But the most important use of the fat is in the process of nutrition. Composed chiefly of carbon and hydrogen, it is absorbed into the blood and consumed in respiration, combining with oxygen to form carbonic acid and water, and thus contributing with other hydrocarbonous matters to maintain the heat of the body; and it is supposed that when the digestive process introduces into the system more carbon and hydrogen than is required for immediate consumption, the excess of those elements is stored up in the form of fat, to become available for use when the expenditure exceeds the immediate supply. According to this view, active muscular exercise, which increases the respiration, tends to prevent the accumulation of fat by increasing the consumption of the hydrocarbonous matter introduced into the body. Again, when the direct supply of calorific matter for respiration is diminished or cut off by withholding food, or by interruption of the digestive process, nature has recourse to that which has been reserved in the form of fat; and in the wasting of the body caused by starvation, the fat is the part first consumed.

The use of the fat in nutrition is well illustrated by what occurs in the hedgehog and some other hybernating animals. In these the function of alimentation is suspended during their winter sleep, and though their respiration is reduced to the lowest amount compatible with life, and their temperature falls, there is yet a considerable amount of hydrocarbonous material provided in the shape of fat before their hybernation commences, to be slowly consumed during that period, or perhaps to afford an immediate supply on their respiration becoming again active in spring.

It has been estimated that the mean quantity of fat in the human subject is about one-twentieth of the weight of the body, but from what has been said, it is plain that the amount must be subject to great fluctuation. The proportion is usually largest about the middle period of life, and greatly diminishes in old age. High feeding, repose of mind and body, and much sleep, favour the production of fat. To these causes must be added individual and perhaps hereditary predisposition. There is a greater tendency to fatness in females than males; also, it is said, in eunuchs. The effect of castration in promoting the fattening of domestic animals is well known.

In infancy and childhood the fat is confined chiefly to the subcutaneous tissue. In after-life it is more equally distributed through the body, and in proportionately greater quantity about the viscera. In Hottentot females fat accumulates over the gluteal muscles, forming a considerable prominence; and, in a less degree, over the deltoid. A tendency to local accumulations of the subcutaneous fat is known to exist also in particular races of quadrupeds.

Development.—According to Valentin, the fat first appears in the human embryo about the fourteenth week of intra-uterine life. At this period fat is deposited in cells already formed in the tissues. The cells first seen are for the most part insulated, but by the end of the fifth month they are collected into small groups. They are also at first of comparatively small size. As already stated, the fœtal fat-cells contain a nucleus in their early condition which is afterwards hidden from view.

It has been a question whether, when the fat undergoes absorption, the vesicles are themselves consumed along with their contents. Dr. W. Hunter believed that they still remained after being emptied; he was led to this opinion by observing the condition of the areolar tissue in dropsical bodies from which the fat had disappeared, there being in such cases a marked difference in aspect between the parts of that tissue which had originally contained fat and those which had not, which difference he attributed to the persistence of the empty fat vesicles. Gurlt states that the fat-cells in emaciated animals are filled with serum, and this statement is fully confirmed by the observations of Kölliker, Todd and Bowman, myself, and others.

CONNECTIVE TISSUE.

This substance consists of fibres of two kinds, more or less amorphous matter, and peculiar corpuscles. By means of its fibres it serves in the animal body as a bond of connection of different parts; also as a covering or investment to different organs, not only protecting them outwardly, but, in many cases entering into their structure and connecting and supporting their component parts. The corpuscles, on the other hand, are destined for other than mechanical purposes; they appear to be essentially concerned in the nutrition and reparation of tissues.

Three principal modifications or varieties of connective tissue have long been recognized, consisting of the same structural elements but in widely different proportions, and thereby exhibiting a difference in their grosser or more obvious characters and physical properties. They are known as the *areolar*, the *fibrous*, and the *elastic* tissues, and will be now severally treated of. Without disregarding the alliance of cartilage and bone to the connective tissues, we shall not, in imitation of some respected authorities, include them in the same group; but there remain certain forms of tissue, occurring locally, or met with as constituents of other textures, which properly belong to this head, and will be briefly considered in a separate section as subordinate varieties of connective tissue.

Cartilage and bone are included in the group of connective tissues or connective substances by several eminent German histologists, and present undoubted points of relationship with these tissues, both in their nature and the general purpose which they serve in the animal frame. Thus, yellow cartilage shows an unmistakable transition to elastic connective tissue, as fibro-cartilage does, even more decidedly, to white fibrous tissue. Moreover, the animal basis of bone agrees entirely in chemical composition, and in many points of structure, with the last named tissue. Still, when it is considered that cartilage, in its typical form, consists of a quite different chemical substance, chondrin, and that bone is characterized by an impregnation of earthy salts, it seems more consistent with the purpose of histological description to recognise cartilage and bone as independent tissues. As to their community of origin, little stress need be laid on it as a basis of classification, seeing that the origin of blood-vessels, nerves and muscles, may be traced up to protoplasm-cells, to all appearance similar to those that give rise to the connective tissues, and belonging to the same embryonic layer.

THE AREOLAR TISSUE.

If we make a cut through the skin and proceed to raise it from the subjacent parts, we observe that it is loosely connected to them by a soft filamentous substance, of considerable tenacity and elasticity, and having, when free from fat, a white fleecy aspect; this is the substance known by the names of "cellular," "areolar," "filamentous," "connective," and

"reticular" tissue; it used formerly to be commonly called "cellular membrane." In like manner the areolar tissue is found underneath the serous and mucous membranes which are spread over various internal surfaces, and serves to attach those membranes to the parts which they line or invest; and as under the skin it is named "subcutaneous," so in the last-mentioned situations it is called "subserous" and "submucous" areolar tissue. But on proceeding further we find this substance lying between the muscles, the blood-vessels, and other deep-seated parts, occupying, in short, the intervals between the different organs of the body where they are not otherwise insulated, and thence named "intermediate;" very generally, also, it becomes more consistent and membranous immediately around these organs, and, under the name of the "investing" areolar tissue, affords each of them a special sheath. It thus forms inclosing sheaths for the muscles, the nerves, the blood-vessels, and other parts. Whilst the areolar tissue might thus be said in some sense both to connect and to insulate entire organs, it also performs the same office in regard to the finer parts of which these organs are made up; for this end it enters between the fibres of the muscles, uniting them into bundles; it connects the several membranous layers of the hollow viscera, and binds together the lobes and lobules of many compound glands; it also accompanies the vessels and nerves within these organs, following their branches nearly to their finest divisions, and affording them support and protection. This portion of the areolar tissue has been named the "penetrating," "constituent," or "parenchymal."

It thus appears that the areolar is one of the most general and most extensively distributed of the tissues. It is, moreover, continuous throughout the body, and from one region it may be traced without interruption into any other, however distant; a fact not without interest in practical medicine, seeing that in this way dropsical waters, air, blood, and urine, effused into the areolar tissue, and even the matter of suppuration, when not confined in an abscess, may spread far from the spot where they were first introduced or deposited.

On stretching out a portion of areolar tissue by drawing gently asunder the parts between which it lies, it presents an appearance to the naked eye of a multitude of fine soft elastic threads, quite transparent and colourless, like spun glass; these are intermixed with fine transparent films, or delicate membranous laminæ, and both threads and laminæ cross one another irregularly and in all imaginable directions, leaving open interstices or areolæ between them. These meshes are, of course, more apparent when the tissue is thus stretched out; it is plain also that they are not closed cells, as the term "cellular tissue" might seem to imply, but merely interspaces which open freely into one another: many of them are occupied by the fat, which, however, as already explained, does not lie loose in the areolar spaces, but is enclosed in its own vesicles. A small quantity of colourless transparent fluid is also present in the areolar tissue, but, in health, not more than is sufficient to moisten it. This fluid is generally said to be of the nature of serum; but it is not improbable that, unless when unduly increased in quantity or altered in nature by disease, it may resemble more the liquor sanguinis, as is the case with the fluid of most of the serous membranes.

On comparing the areolar tissue of different parts, it is observed in some to be more loose and open in texture, in others more dense and close, according as free movement or firm connection between parts is to be provided for. In some situations, too, the laminæ are more numerous; in

others the filamentous structure predominates, or even prevails exclusively; but it does not seem necessary to designate these varieties by particular names, as is sometimes done.

When examined under the microscope, the areolar tissue is seen to be principally made up of exceedingly fine, transparent, and apparently homogeneous filaments, from about $\frac{1}{50000}$th to $\frac{1}{25000}$th of an inch in thickness, or even less (fig. XXXV.). These are seldom single, being mostly united by means of a small and usually imperceptible quantity of a homogeneous connecting substance into bundles and filamentous laminæ of various sizes, which to the naked eye, appear as simple threads and films. Though the bundles may intersect in every direction, the filaments of the same bundle run nearly parallel to each other, and no one filament is ever seen to divide into branches or to unite with another. The associated filaments take an alternate bending or waving course as they proceed along the bundle, but still maintain their general parallelism. This wavy aspect, which is very characteristic of these filaments, disappears on stretching the bundle, but returns again when it is relaxed.

The filaments just described, though transparent when seen with transmitted light under the microscope, have a white colour when collected in considerable quantity and seen with reflected light; and they not only occur in the areolar tissue strictly so called, but form the chief part of the tendons, ligaments, and other white fibrous connective tissues. They were long supposed to be the only fibrous constituent existing in the areolar tissue, but it has been shown (and chiefly through the inquiries of Eulenberg, Henle, and Bowman) that fibres of another kind are intermixed with them; these agree in all characters and are obviously identical with the fibres of the yellow elastic tissue, and have accordingly been named the yellow or elastic fibres, to distinguish them from the white or waved filaments above described. They were at one time termed nuclear fibres (Kernfasern), on account of their supposed origin from nuclei; but as it now appears that they have no connection either with nuclei or cells, the latter appellation must be abandoned. Moreover, they differ in chemical nature from cells and nuclei, in as much as they resist the action of boiling alkaline solutions of potash and soda, of moderate strength, which very speedily destroy the cells and nuclei.

Fig. XXXV.

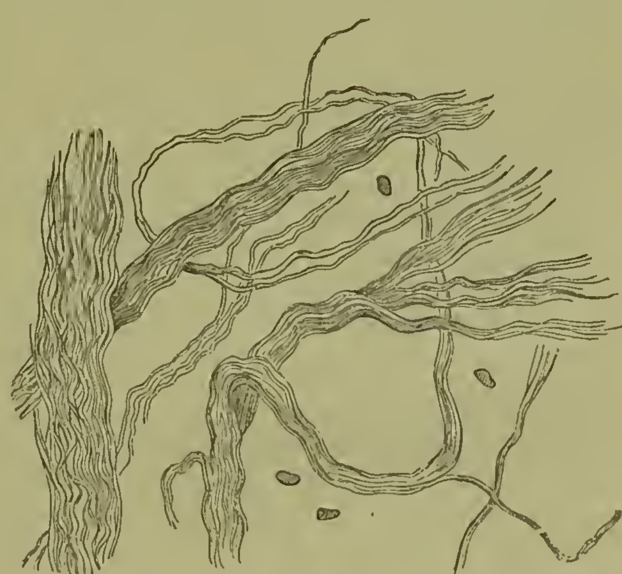


Fig. XXXV.—Filaments of Areolar Tissue, in larger and smaller bundles, as seen under a magnifying power of 400 diameters.

Two or three corpuscles are represented among them.

In certain portions of the areolar tissue, as for instance in that which lies under the serous and mucous membranes of particular regions, the yellow or elastic fibres are abundant and large, so that they cannot well be overlooked; but in other parts they are few in number, and small, and are then in a great measure hidden by the white filaments; in such cases, however, they can always be rendered conspicuous under the microscope by means of acetic acid, which causes the white filaments to swell up and become indistinct, whilst the elastic fibres, not being affected by that reagent, come then more clearly into view (fig. XXXVI.). Under the microscope the elastic fibres appear transparent and colourless, with a strong, well-defined, dark outline. They are, moreover, remarkable for their tendency to curl up, especially at their broken ends, which gives them a very peculiar aspect, and in many parts of the areolar tissue they divide into branches and join or anastomose with one another, in the same manner as in the pure elastic tissue (*a*). They differ among themselves very widely in size, some being as fine as the white filaments, others many times larger.

Fig. XXXVI.

Fig. XXXVI.—Magnified View of Areolar Tissue (from different parts) treated with Acetic Acid.

The white filaments are no longer seen, and the yellow or elastic fibres with the nuclei come into view. At *c*, elastic fibres wind round a bundle of white fibres, which by the effect of the acid is swollen out between the turns.

In the immature areolar tissue of the fœtus there is a considerable amount of soft, jelly-like matter, of muco-albuminous nature, in the interstices of the formed elements. This amorphous substance is for the most part inconspicuous in the perfected tissue, but exists abundantly in the umbilical cord, where it forms the well-known Whartonian jelly; it may also be seen, at all periods, but in smaller quantity, in the areolar tissue within the vertebral canal.

A very different view of the structure of areolar tissue from that here stated was taken by Reichert, and adopted by Virchow, Donders, and other distinguished histologists. According to this view the apparent bundles consist of a substance in reality amorphous or homogeneous, and its seeming fibrillation is partly artificial, the result of cleavage, and partly an optical illusion, arising from creasing or folding. In point of fact, however, the bundles readily separate into fibrils after exposure to dilute solutions of chromic acid, or to lime-water, or to baryta-water, by which the uniting matter is dissolved; so that there can be no doubt of their truly fibrillar structure. At the same time it is not denied that immature fasciculi may probably occur, in which the fibrillation is incomplete. Moreover, a homogeneous substance, not to be confounded with the soft, jelly-like matter previously noticed, but of firm consistence and agreeing in chemical nature with the fibrils, envelopes the fasciculi in some situations in form of a fine

sheath (Kölliker); and it will be afterwards noticed as constituting a special form or variety of connective tissue occurring elsewhere.

The elastic fibres lie, for the most part, without order, among the bundles of white filaments; but here and there we see an elastic fibre winding round one of these bundles, and encircling it with several spiral turns. When acetic acid is applied, the fasciculus swells out between the constricting turns of the winding fibre, and presents a highly characteristic appearance (*c*). This remarkable disposition of the elastic fibres, which was pointed out by Henle, is not uncommon in certain parts of the areolar tissue; it may be always seen in that which accompanies the arteries at the base of the brain. It must be observed, however, that the encircling fibre sometimes forms not a continuous spiral, but several separate rings; moreover, the whole appearance is explained by some histologists on the supposition that the bundles in question are naturally invested with a delicate sheath, which, like the elastic tissue, resists acetic acid, but, on the swelling up of the bundle under the operation of that agent, is rent into shreds or segments, mostly annular or spiral, which cause the constrictions. Kölliker, who admits that some fasciculi have a sheath, yet supposes that in these, as well as in naked bundles, the encircling fibres are produced by prolongations from the corpuscles (to be immediately noticed), uniting in form of a thread, or of a network wrapped round the bundle.

Bodies, mostly with nuclei, and of the nature of cells, although not shown to possess a distinct cell-wall, are found in the areolar tissue. These are the *connective-tissue corpuscles.* Some lie in the meshes of the tissue, others are included within the fasciculi. The former are of no very regular shape, rounded or oval (as in fig. XXXIV.), or, as described in the frog by Kühne, having a stellate or jagged outline with processes or offsets of unequal size and length, here and there connected with processes from neighbouring corpuscles:—in short, misshapen little masses of protoplasm, but containing usually a well-formed oval nucleus and conspicuous nucleolus. Those within the fasciculi are fusiform, with pointed ends, and lie lengthwise in the direction of the fasciculus (as shown, though imperfectly, in fig. XXXVI. *c.*).

These bodies were imagined to be hollow, and by the intercommunication of their supposed tubular offsets, it was conceived that they formed a system of reticulating canals destined to distribute nutritive fluid to the connective tissue and other parts into which that tissue enters. But, though soft, they are evidently solid objects, and though they probably effect some chemical change, or exert some other influence on the interstitial nutritive plasma, or in some other way minister to nutrition, it is clearly not as a system of channels for the conveyance of fluid. In the frog they exhibit slow but distinct movements and changes of shape, like the pale blood-corpuscles; and they may be regarded as cells retaining their primitive protoplasmic condition, and subservient not only to the nutrition, but to the extension and repair of tissues. There can be little doubt, moreover, that they are largely concerned in pathological and degenerative, as well as in reparative processes.

The areolar tissue contains a considerable quantity of water, and consequently loses much of its weight by drying. It is almost wholly resolved into gelatine by boiling in water. Acetic acid causes it, that is, the bundles of white fibrils, to swell up into a soft, transparent, jelly-like mass.

Numerous blood-vessels are seen in the areolar tissue after a minute injection. These for the most part only pass through it on their way to other more vascular textures, but a few seem to end in capillaries destined for the tissue itself, and dense clusters of vessels are distributed to the fat lobules. Large lymphatic vessels proceeding to distant parts also pass along this texture, and abundant lymphatic networks may be discovered in many parts of the subcutaneous, subserous, and submucous areolar tissue, having

evident relation to the function of the membranes under which they lie. Absorption readily takes place from the interstices of the texture, but that process may be effected through the agency of blood-vessels as well as of lymphatics.

Larger and smaller branches of nerves also traverse this tissue on their way to other parts ; but it has not been shown that any remain in it, and accordingly it may be cut in a living animal apparently without giving pain, except when the instrument meets with any of these traversing branches. It is not improbable, however, that nerves end in those parts of the areolar tissue which, like that of the scrotum, contain contractile fibres ; but, if present in such cases, the nerves, like the vessels of the fat, are, after all, destined not to the areolar tissue but to another mixed with it.

The physical properties of this texture have been sufficiently indicated in the foregoing description ; also its want of sensibility. The vital contractility ascribed to certain portions of it is most probably due to the presence of muscular tissue.

With the exception of the epithelium, no tissue is so readily regenerated as the areolar. It is formed in the healing of wounds and in the adhesion of inflamed surfaces. It is produced also in many morbid growths.

FIBROUS TISSUE.

This substance is one of those which are serviceable in the body chiefly on account of their mechanical properties, being employed to connect together or to support and protect other parts. It is met with in the form of ligaments, connecting the bones together at the joints ; it forms the tendons of muscles, into which their fleshy fibres are inserted, and which serve to attach these fibres to the bones. In its investing and protecting character it assumes the membranous form, and constitutes a class of membranes termed "fibrous." Examples of these are seen in the periosteum and perichondrium which cover the bones and cartilages, in the dura mater which lines the skull and protects the brain, and the fibrous layer which strengthens the pericardium, also in the albugineous coat of the testicle, and the sclerotic coat of the eye, which inclose the tender internal parts of these organs. Fibrous membranes, named "aponeuroses" or "fasciæ," are also employed to envelope and bind down the muscles of different regions, of which the great fascia inclosing the muscles of the thigh and leg is a well-known example. The tendons of muscles, too, may assume the expanded form of aponeuroses, as those of the broad muscles of the abdomen, which form strong fibrous layers in the walls of that cavity and add to their strength. It thus appears that the fibrous tissue presents itself under two principal forms, the *fasicular* and the *membraneous*.

Physical Properties.—The fibrous tissue is white or yellowish white, with a shining, silvery, or nacreous aspect. It is exceedingly strong and tough, yet perfectly pliant ; but it is almost devoid of extensibility. By these qualities it is admirably suited to the purposes to which it is applied in the animal frame. By its inextensible character it maintains in apposition the parts which it connects against any severing force short of that sufficient to cause actual rupture, and this is resisted by its great strength, whilst its flexibility permits of easy motion. Accordingly the ligaments and tendons do not sensibly yield to extension in the strongest muscular efforts ; and though they sometimes snap asunder, it is well-known that bones will break more readily than tendons of equal thickness. The fibrous membranes are proportionally strong and alike inextensible ; they will gradually yield, it is

true, when the extending force acts slowly and for a long time, as when tumours or fluids slowly gather beneath them; but perhaps this gradual extension is accompanied with some nutritive change affecting the properties of the tissue.

Structure.—The fibrous tissue is made up of fine filaments, agreeing in all respects with the white filaments of the areolar tissue already described. Like these they are collected into bundles, in which they run parallel and exhibit the same wavy character, cohering very intimately. The bundles appear to the naked eye as fine shining threads or narrow flattened bands, for they vary greatly in thickness. They either run all in one direction as in long tendons, or intersect each other in different planes as in some aponeuroses, or they take various directions and decussate irregularly with each other as in the dura mater. And when they run parallel to each other, as in tendon, they do not keep separate throughout their length, but send off slips to join neighbouring bundles and receive the like in turn; so that successive cross sections of a tendon or ligament present different figures of the sectional areas of the bundles. A sheath of dense areolar tissue covers the tendons and ligaments on the outside, and a variable amount of the same tissue lies between the larger fasciculi; little in tendons, more in some fibrous membranes.

The filaments swell up and become indistinct when acted on by acetic acid, like those of areolar tissue, and here also the acid discloses the existence of corpuscles and of elastic fibres, intermixed in small proportion with the rest of the tissue. The elastic fibres are fine and generally branched and connected together. The corpuscles, which have no real connection with the elastic fibres, are for the most part lodged where the angles of the fasciculi (which are usually prismatic in form) meet. They are fusiform or lanceolate in figure, pointed at the ends, and lie lengthwise among the bundles. In cross sections there is an appearance of radiating pointed processes, diverging from the spots where the corpuscles are situated, and these have been taken for branches or offsets extending laterally from these bodies; but it seems to be satisfactorily shown that the apparent branches are merely the crevices between the fasciculi, diverging from the point where their angles meet. But although these fissures do not contain branches radiating from the corpuscles, flat membraneous shreds can here and there be extracted from them, which are by some supposed to be part of a membrane by which each several bundle is ensheathed and separated from its neighbours.

The surface of a tendon or of any other part consisting of this texture, appears marked across the direction of the fasciculi with alternate light and dark streaks, which give it a peculiar aspect, not unlike that of a watered ribbon. This appearance is owing to the wavy course of the filaments, for when the light falls on them their bendings naturally give rise to alternate lights and shadows.

The fibrous and areolar tissues thus agreeing in their ultimate structure, it is not to be wondered at that sometimes the limits between the two should be but ill defined, and that the one should pass by inconspicuous gradations into the other. Instances of such a transition may be seen in many of the fasciæ; these at certain parts consist of dense areolar tissue, but on being traced farther are seen gradually to take on the fibrous character; and fasciæ, which in one body consist of areolar tissue, may be decidedly fibrous in another.

In chemical constitution also the fibrous tissue is similar to the areolar. It contains about two-thirds of its weight of water; it becomes transparent,

hard, and brittle, when dried, but readily imbibes water again and regains its original properties. It is resolved into gelatin by boiling.

The fibrous tissue receives blood-vessels, but in general they are inconsiderable both in number and size compared with the mass of tissue to which they belong. In tendons and ligaments with longitudinal fasciculi, the chief branches of the vessels run parallel with and between the larger fasciculi, and, sending communicating branches across them, eventually form a very open network with large oblong meshes. Some fibrous membranes, as the periosteum and dura mater, are much more vascular ; but the vessels seen in these membranes do not strictly belong to them, being destined for the bones which they cover. The lymphatics of fibrous tissue, are not sufficiently known to be spoken of with certainty.

As to nerves, their general existence in this texture has not been satisfactorily demonstrated by anatomical investigation. Recent inquiries into this subject have shown that the smaller tendons contain no nerves, and the larger only such nervous filaments as accompany and belong to the vessels ; and the same is true of the ligaments. The fasciæ and the sheaths of tendons are also destitute of nerves. On the other hand, fine nerves have been traced in the interosseous membrane of the leg, and nervous filaments are even abundant in the periosteum, but the majority of them do not belong to the membrane itself, but are destined for the subjacent bone. Nerves have also been traced in the dura mater ; some accompany the vessels, others appear destined for the membrane itself, and others again for the bones.

It has been proved by numerous observations and experiments, that the tendons, ligaments, and other structures composed of fibrous tissue, are, in the healthy state, quite insensible ; but then it is known, on the other hand, that they occasion severe pain when inflamed, which cannot well be accounted for on the supposition that they are entirely destitute of nerves. Bichat, while he admitted their insensibility to cutting, burning, and most other kinds of stimuli which cause pain in sensible textures, ascribed to them a peculiar sensibility to twisting or to violent extension, and this opinion has been supported by other authorities of weight, but the proofs of it are not clear.

It readily heals and unites when divided, as is seen in cases of broken tendo Achillis. Fibrous tissue is very generally produced as a uniting medium of broken bones when osseous union fails to take place ; it is common as a diseased production in various kinds of tumours.

YELLOW OR ELASTIC TISSUE.

Whilst the fibrous tissue is remarkable for its want of extensibility, and owes its usefulness as a constituent of the frame in a great measure to that character, the substance we have now to consider possesses this property in a very high degree, and is employed wherever an extensible and highly elastic material is required in the animal structure.

Examples of this texture on a large scale are seen in the horse, ox, elephant, and other large quadrupeds, in which it forms the great elastic ligament, called *ligamentum nuchæ*, that extends from the spines of the vertebræ to the occiput, and aids in sustaining the head ; in the same animals it also forms an elastic subcutaneous fascia, which is spread over the muscles of the abdomen and assists in supporting the contents of that cavity. In the human body it is met with chiefly in the following situations, viz. :—

1. Forming the *ligamenta subflava*, which extend between the arches of adjacent vertebræ; these ligaments, while they permit the bones to be drawn apart in flexion of the body, aid in restoring and maintaining their habitual approximation in the erect posture—so far, therefore, relieving the constant effort of the erector muscles. 2. Constituting the chief part of the stylohyoid, thyrohyoid, and cricothyroid ligaments, and those named the vocal cords. Also extending, in form of longitudinal bands, underneath the mucous membrane of the windpipe and its ramifications. 3. Entering, along with other textures, into the formation of the coats of the blood-vessels, especially the arteries, and conferring elasticity on these tubes. 4. Beneath the mucous membrane of the gullet and lower part of the rectum, also in the tissue which surrounds the muscular coat of the gullet externally. 5. In the tissue which lies under the serous membranes in certain parts. 6. In many of the fasciæ, where it is mixed with much areolar tissue. 7. Largely in the suspensory ligament and subcutaneous tissue of the penis. 8. In considerable quantity in the tissue of the skin.

The elastic tissue in its purest and most typical condition, such as is seen in the ligamentum nuchæ of quadrupeds and the ligamenta subflava of the human spine, has a yellow colour more or less decided; it is extensible and elastic in the highest degree, but is not so strong as ordinary fibrous ligament, and it breaks across the direction of its fibres when forcibly stretched. Its fibres may be easily torn separate in a longitudinal direction; they are often gathered into irregular fasciculi which run side by side but join at short distances by slips with one another, and are further connected by areolar tissue, which is always intermixed with them in greater or less quantity. Elastic ligaments are also covered outwardly with a sheath of areolar tissue.

When the elastic fibres are mixed up with a large proportion of some other kind of tissue, their yellow colour may not appear, but they can always be recognised by their microscopic characters. When viewed under a tolerably high magnifying power, they appear quite transparent, with a remarkably well-defined dark outline (fig. XXXVII.). They run side by side, following a somewhat bending course, but with bold and wide curves, unlike the undulations of the white connective filaments. As they proceed they divide into branches, and join or anastomose together in a reticular manner. Elastic networks may be composed of fine fibres with wide meshes, and this is the character of all at first; but while some continue in this state, in others the elastic fibres grow larger and broader and the intervening spaces narrower, so that the tissue may acquire a lamellar character and present the appearance of a homogeneous membrane, which may be either entire, or with gaps or perforations at short intervals, in which case it constitutes the fenestrated membrane of Henle, found in the coats of the blood-vessels. A remarkable character which elastic fibres exhibit in many specimens, is their singular tendency to curl up at their broken ends; and these

Fig. XXXVII.

Fig. XXXVII.—Elastic Fibres from the Ligamenta Subflava, magnified about 200 diameters.

ends are not pointed, but abruptly broken across. Their size is very various; the largest in man are nearly $\frac{1}{4000}$th of an inch in diameter, the smallest perhaps not more than $\frac{1}{24000}$th. In some varieties of the tissue the larger sized fibres prevail; this is the case with the ligamenta subflava, where their general diameter is about $\frac{1}{7500}$th of an inch; in other instances, as in the chordæ vocales, they are exceedingly fine. In some animals elastic fibres are met with $\frac{1}{1500}$th of an inch in thickness. Acetic acid produces no change on the elastic fibres, while it speedily alters the wavy areolar fibres that are usually intermixed with them in greater or less number. They also withstand boiling for a short time in solutions containing ten to fifteen per cent. of caustic potash or soda, by which the white fibres and the corpuscles of connective tissue are speedily destroyed.

The elastic tissue, of course, contains water, and loses much of its weight by drying; but the proportion is said not to be so great as in most other soft tissues. By very long boiling it yields a substance in some points resembling gelatin, while a portion, equal to rather more than the half, remains undissolved.

The gelatin, no doubt, comes from the intermixed areolar tissue; but the dissolved matter is not pure gelatin, for it is precipitated by acetic acid, and by some other reagents which do not disturb a solution of pure gelatin. The nature of the substance which remains undissolved has not been determined. Caustic potash and soda have little effect on elastic tissue in the cold, and in weak solutions even when hot, unless the application is long continued; boiling in concentrated solutions speedily dissolves it. It is soluble with the aid of heat in dilute hydrochloric acid.

Little is known respecting the blood-vessels and nerves of this texture. The yellow ligaments which contain it in its purest form, are but scantily supplied with vessels; and no nerves have been traced into them. I am not aware of any experiments or observations as to their sensibility, but there is no reason for supposing it to be greater than that of ordinary ligaments; nor has it been shown that structures containing this tissue possess vital contractility, unless they also contain contractile fibres of another kind.

SPECIAL VARIETIES OF CONNECTIVE TISSUE.

1. *Jelly-like connective tissue*, or *mucous tissue*. In the early embryo the areolar tissue consists of a pellucid jelly and nucleated corpuscles. The soft, watery jelly contains the chemical principle of mucus, or *mucin*, and, in much less proportion, albumen, but no gelatin. In the general course of development of the tissue, fibres, both white and elastic, are formed in the soft matrix, and finally this substance entirely or in a great measure disappears. But in certain cases the course is different. The cells may disappear, only the jelly remaining, as in the vitreous humour of the eye; or the corpuscles may branch out and join together in form of a network in the jelly, with the persisting nuclei at the spots whence the threads diverge. Such a condition is seen in the enamel-organ of growing teeth. The areolar tissue surrounding and imbedding the vessels in the umbilical cord consists of fusiform and ramified corpuscles associated with white fibrillar bundles and elastic fibres, along with much of the soft matrix, which is persistent at the time of birth and constitutes the jelly of Wharton.

2. *Retiform** *connective tissue*; *Reticular tissue*, and *Cytogenous tissue* (Kölliker); *Adenoid tissue* (His). In this case the matrix disappears; neither white nor elastic fibres are developed, but the ramified corpuscles unite together into a reticular or fine trabecular structure (fig. XXXVIII.); either retaining their nuclei as at *a*, or losing them and then forming a fine network of simple fibres without nuclei, as at *b*.

That in both forms the tissue is constructed of ramified corpuscles is shown by its withstanding boiling in water, whilst it readily dissolves in hot alkaline solutions. This form of connective tissue enters into the construction of certain organs and textures, where it serves as a supporting framework to their peculiar elements and their nourishing blood-vessels, and thus becomes a "sustentacular" tissue (*Stützgewebe*, Germ.). In this way it forms a trabecular network within the lymphatic glands, containing the lymph or chyle corpuscles in its meshes (as at *c*). So also it is found in the solitary and agminated follicular glands of the intestine, the tongue and tonsils; in the thymus gland; in the pulp and Malpighian bodies of the spleen, and in the tissue of the intestinal mucous membrane at certain parts; in all which situations the meshes contain corpuscles of similar external character with those in the lymphatic glands. But although thus related to glands and thence named "adenoid" tissue, it exists also as a sustaining structure in the brain and spinal cord, where, with finer branches and closer meshes, it forms an extremely delicate framework supporting the proper nervous substance, and has been called the *reticulum* (Kölliker).

Fig. XXXVIII.

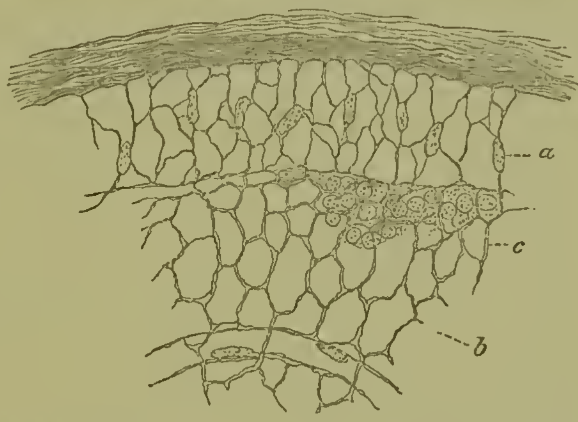


Fig. XXXVIII.—Thin Section from the Cortical Part of a Lymphatic Gland, magnified.

A network of fine trabeculæ formed by retiform or adenoid tissue, from the meshes of which the lymph-corpuscles have been washed out, except at *c*, where they are left (after His, slightly altered).

3. *Homogeneous connective tissue*. More consistent than the mucous or jelly-like tissue, and differing also in chemical nature, inasmuch as it appears to be collagenous (*i. e.*, yielding gelatin), and thus more nearly related in substance to the white fibrillar tissue. It contains no fibres or fibrils, and may be quite transparent and uniform in character, or faintly granular and striated. For the most part this substance occurs in the form of *homogeneous membranes*; examples of which are found in the external coat of fine vessels, the hyaloid membrane in the eye, the capsules of the Malpighian bodies in the kidney and spleen, the capsules of the solitary and agminated intestinal glands and the lingual and tonsillar follicular glands, in the Graafian follicles, and in certain gland-ducts. It must be noted, however, that some homogeneous membranes, as, for example, the posterior elastic lamina of the cornea, are of a different nature.

* I use the term "retiform," not because it signifies more or less than "reticular," but because the latter term is not unfrequently applied to areolar tissue.

DEVELOPMENT OF CONNECTIVE TISSUE.

In those parts of the embryo where connective tissue is to be developed, there is at first a deposit of nucleated corpuscles, having the characters common to the cells of which the early embryo-body throughout consists. Between the cells is a small amount of soft amorphous intercellular substance, which increases in quantity. This is at first of a muco-albuminous nature, but is in great part changed into a gelatinous substance, which assumes a fibrillar character, and becomes converted into the bundles of white wavy filaments that constitute the chief part of the areolar and fibrous tissues. These bundles, after their first appearance, increase in size, and continue to grow larger after birth. Amongst these white fasciculi, elastic fibres, in varying proportion, appear at a somewhat later period. These are also produced from the intercellular substance, which in this case undergoes a different chemical change. They appear from the first in form of networks pervading the intercellular mass throughout, and not as single shorter fibres gradually lengthening out and joining together; nor do they appear to be formed by the linear coalescence of granules, but by immediate differentiation in the intercellular substance. The elastic fibres are at first exceedingly fine, but acquire greater thickness as development advances, and in some situations what was originally a network may become an elastic membrane. The cells in part remain as the connective-tissue corpuscles already described; irregularly ramified in open areolar tissue, but fusiform within the bundles and in the interstices of dense fibrous tissue; part of them become filled with fat, and form the adipose tissue. The intercellular substance is usually reduced to an inconspicuous amount, but in some situations remains in notable quantity.

Such is the most general course of development; but, as will be understood from what has preceded, it is different in particular cases. Thus, the intercellular substance may accumulate in large proportion, and the cells finally disappear, as in the vitreous humour; or the cells may be developed into retiform or cytogenous tissue, without the formation of fibres, either white or elastic, in which case the jelly-like substance may remain, as in the enamel-organ; or the reticular interstices may become filled with the elements of another tissue, as in the lymphatic glands and nervous centres. In the development of the pure elastic ligaments the cells shrink as the elastic fibres grow larger, and at length disappear altogether.

The intercellular substance may be excreted by the cells, but there is no clear proof of this; it may be an independent deposit between them; and the disappearance of the cells from pure elastic ligament would seem to show that, whatever be the influence they exert in the original formation, they are not needed for carrying on the nutrition, or even for the further growth of the tissue.

The foregoing account of the formation of connective tissue is derived from Kölliker's latest observations;* but Max Schultze considers that the intercellular substance, or matrix, is neither excreted by the cells, nor deposited ab extra, but is in reality formed by conversion of part of the protoplasm which forms the bodies of the cells (nucleated protoplasm masses): the matrix thus increases and becomes fibrillated at the expense of the cells, which, now reduced to the nuclei surrounded with a small portion of protoplasm, remain as the connective-tissue corpuscles.

CARTILAGE.

This is the well-known substance commonly called "gristle." The following are its more obvious characters. When in mass, it is opaque and of a pearly or bluish white colour, in some varieties yellow; but in thin slices it is translucent. Although it can be easily cut with a sharp knife, it is nevertheless of very firm consistence, but at the same time highly elastic, so that it readily yields to pressure or torsion, and immediately recovers its original shape when the constraining force is withdrawn. By reason of

* Neue Untersuchungen über die Entwickelung des Bindegewebes. Würzb. naturwiss. Zeitschr., vol. ii. Also Handbuch der Gewebelehre, 4th edit. 1863.

these mechanical properties, it is rather extensively used in the construction of the body. Its specific gravity is 1·15.

In the early embryo the skeleton is, in great part, cartilaginous ; but the cartilage forming its different pieces, which have the outward form of the future bones, in due time undergoes ossification or gives place to bone, in the greater part of its extent at least, and hence this variety of cartilage is named "temporary."

Of the permanent cartilages a great many are in immediate connection with bone, and may be still said to form part of the skeleton. The chief of these are the articular and the costal cartilages ; the former cover the ends or surfaces of bones in the joints, and afford these harder parts a thick springy coating, which breaks the force of concussion and gives ease to their motions ; the costal or rib-cartilages form a considerable part of the solid framework of the thorax, and impart elasticity to its walls. Other permanent cartilages enter into the formation of the external ear, the nose, the eyelids, the Eustachian tube, the larynx, and the windpipe. They strengthen the substance of these parts without undue rigidity ; maintaining their shape, keeping open the passages through them where such exist, and giving attachment to moving muscles and connecting ligaments.

Cartilages, except those of the joints, are covered externally with a fibrous membrane named the *perichondrium.*

When a very thin slice of cartilage is examined with the microscope, it is seen to consist of nucleated cells, also named cartilage corpuscles, disseminated in a solid mass or matrix. (Figs. XXXIX., XL., and XLI.)

The matrix is sometimes transparent, and to all appearance homogeneous; sometimes dim and very faintly granular, like ground glass : both these conditions occur in *hyaline cartilage,* which may be regarded as the most typical form of the tissue. Two varieties exist in which the matrix is pervaded to a greater or less extent by fibres. In the one, named *elastic* or *yellow cartilage,* the fibres are similar to those of elastic tissue ; in the other, named *fibro-cartilage,* they are of the white kind as in ordinary ligament.

HYALINE CARTILAGE.

In hyaline cartilage the matrix, as just stated, is uniform and, in the normal state, free from fibres. The cells consist of a rounded, oval, or bluntly angular *cell-body* of translucent, but sometimes finely granular-looking substance, with a clear round *nucleus* and one or more *nucleoli.* The cell-body lies in a cavity of the matrix, which, in its natural condition, it entirely fills. This cavity is bounded and inclosed by a transparent *capsule,* which is seldom obvious to the eye, for it coheres intimately with the surrounding matrix, with which it agrees in nature, and cannot usually be distinguished without the aid of re-agents. The capsule has been regarded as a secondary cell-wall and compared to the cellulose wall of vegetable cells ; while the body it contains is, on the same view, considered to be homologous with the primordial utricle and its contents. But the same doubt prevails here as in the case of vegetables, as to the existence of a proper membrane (the utricle) immediately investing the substance of the cell. (See page xiv, and figures VIII. and IX.)

In thin slices of young cartilage the capsules may be freed from the matrix by means of concentrated mineral acids, and can then be shown as distinct vesicles

having the cell-bodies within. The effect of acids is promoted by previous boiling of the cartilage in water. By exposure to water and some other liquids the cell-body shrinks away from the inside of the capsule, and assumes a jagged or otherwise irregular figure, and then may hide the nucleus. It often contains larger or smaller fat globules.

The cells are rarely dispersed singly in the matrix; they usually form groups of different shapes and sizes. Towards the surface of the cartilage the groups are generally flattened conformably with the surface (fig. XL.), appearing narrow and almost linear when seen edgeways, as in a perpendicular section. (Fig. XXXIX., *a.*) The cells in a group have a straight outline where they adjoin or approach one another, but at the circumference of the group their outline is rounded.

Such is the structure of hyaline cartilage in general, but it is more or less modified in different situations.

Fig. XXXIX.

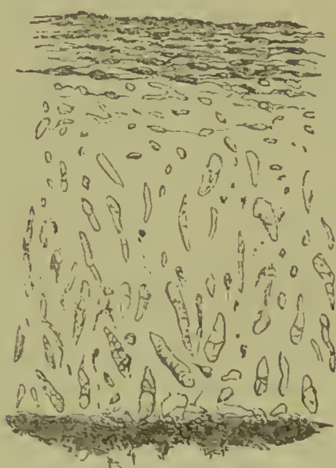


Fig. XL.

Fig. XXXIX.—Diagram representing a Vertical Section of Articular Cartilage, seen with a low magnifying power.

a, Flattened groups of cells near the surface; *b*, oblong groups, for the most part directed vertically; *c*, part of the bone.

Fig. XL.—A Thin Layer peeled off from the Surface of the Cartilage of the Head of the Humerus, showing Flattened Groups of Cells.

The shrunken cell-bodies are distinctly seen, but the limits of the capsular cavities where they adjoin one another are but faintly indicated. Magnified 400 diameters.

In *articular cartilage*, the matrix in a thin section appears dim, like ground glass, and has an almost granular aspect. The cells and nuclei are small. The groups which they form are flattened at and near to the surface, and lie parallel with it (fig. XXXIX., *a*, and fig. XL.); deeper and nearer the bone, on the other hand, they are narrow and oblong, like short strings of beads, and are mostly directed vertically. (Fig. XXXIX., *b*, fig. XL.) It is well known that articular cartilages readily break in a direction perpendicular to their surface, and the surface of the fracture appears to the naked eye to be striated in the same direction, as if they had a columnar structure; this has been ascribed to the vertical arrangement of the rows of cells, or to a latent fibrous or columnar disposition of the substance of the matrix (Leidy). It was formerly held that the free surface of articular cartilage is covered with epithelium continued

from that of the synovial membrane, a thin stratum of areolar tissue being interposed; but the existence of such a covering is certainly not general, at least in the adult. It is easy, no doubt, to peel off a thin film from the surface of the cartilage of the head of the humerus or femur; but this superficial layer is really part of the cartilage, and its broad patches of cells with the intermediate matrix are not to be mistaken. (See fig. XL.) At the same time, it is true that near the margin of these cartilages a layer of fine filamentous tissue, covered with epithelium, is prolonged a certain way over their surface from the synovial membrane. The matrix of articular cartilage rarely, or perhaps never, becomes pervaded by fibres like those so often seen in rib-cartilage, nor is it prone to ossify.

Fig. XLI.

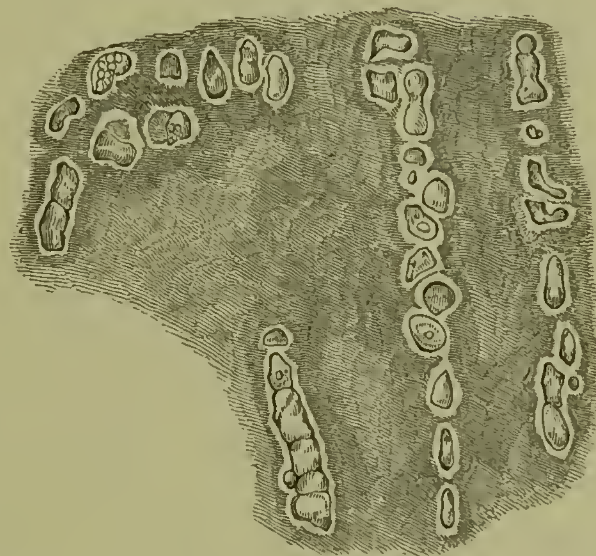


Fig. XLI.—Vertical Section of Articular Cartilage of the Head of the Humerus.

A deep portion near the bone. Magnified 400 diameters. Each cell-cavity contains a mass shaped like itself, the shrunken cell body, in the midst of which a round nucleus is probably concealed.

In the *cartilages of the ribs*, the corpuscles or cells, which are of large size, are also collected in groups. Near the exterior of the cartilage they are flattened, and lie parallel with the surface, forming a superficial stratum from $\frac{1}{200}$ to $\frac{1}{300}$ of an inch thick. As to those situated more inwardly, we can sometimes observe, in a transverse slice, that they form oblong groups disposed in lines radiating to the circumference; but this arrangement is not constant, and they often appear quite irregular. The cells, with the exception of those lying upon the surface, commonly contain larger or smaller drops of oil; and the nucleus being generally undiscoverable, is concealed by the fat or may itself have undergone a fatty metamorphosis. The matrix is tolerably clear, except where fibres have been developed in it, in which parts it is opaque and yellowish. Such fibrous patches are very frequent; the fibres are fine, straight, and parallel, appearing transparent when few together; they withstand the action of acetic acid. It is not uncommon to find the rib cartilages extensively ossified.

It was observed by Herissant * that the costal cartilages, after many months' maceration in putrid water, would sometimes break up into thin plates, directed across the axis of the cartilage; from which he inferred that these cartilages were naturally made up of such transverse lamellæ: but the point does not appear to have been further investigated.

The description given of the microscopic characters of the costal cartilages will apply with little variation to the ensiform cartilage of the sternum, to

* Mém. de l'Acad. des Sc. de Paris, 1748.

the cartilages of the larynx and windpipe, except the epiglottis and cornicula laryngis, and to the cartilages of the nose. With the exception of the last, these resemble the rib-cartilages also in their tendency to ossify.

The characters of the temporary cartilages, which are hyaline, will be given in the account of the formation of bone.

No nerves have been traced into any of the cartilages, and they are known to be destitute of sensibility.

In the healthy state, no bloodvessels penetrate the articular cartilages. Whatever nutrient fluid they require seems to be derived from the vessels of adjoining textures, especially the bone, and to be conveyed through the tissue by imbibition. In the embryo, a layer of vessels is prolonged some way over the surface, underneath the synovial membrane; but, as development proceeds, these sub-synovial vessels retire towards the circumference of the cartilage, and eventually form a narrow vascular border round it, which has been named the *circulus articuli vasculosus*.

When the tissue exists in thicker masses, as in the cartilages of the ribs, canals are here and there excavated in its substance, along which vessels are conducted to supply nourishment to the part too distant to receive it from the vessels of the perichondrium. But these canals are few and wide apart, and the vessels do not pass beyond them to ramify in the intermediate mass, which is accordingly quite extra-vascular. It must be further remembered respecting these vascular canals, that many of them lead to spots where the cartilage is undergoing ossification, and convey vessels to supply the bony deposits.

Ordinary permanent hyaline cartilage contains about three-fifths of its weight of water, and becomes transparent by drying. By boiling it in water for fifteen or twenty hours it is resolved into chondrin. This is a substance said to gelatinise on cooling, although it may be doubted whether the congelation is not in reality owing to an admixture of gelatin derived from fibrous tissue not duly separated from the cartilage. Like gelatine, chondrin is thrown down from its solutions by tannic acid, alcohol, ether, creosote, and corrosive sublimate, and not by prussiate of potash. It differs from gelatin in being precipitated by the mineral and other acids, the acetic not excepted; also by alum, sulphate of alumina, persulphate of iron, and acetate of lead; the precipitates being soluble in an excess of the respective precipitants. The temporary cartilages are resolved into a matter which has the chemical reactions of chondrin, but does not gelatinise. Cartilage affords by incineration a certain amount of mineral ingredients; 3·4 per cent. of ashes were obtained from costal cartilages by Frommherz and Gugert, and 100 parts of these ashes were found to consist of

Carbonate of soda	35·07
Sulphate of soda	24·24
Chloride of sodium	8·23
Phosphate of soda	0·92
Sulphate of potash	1·20
Carbonate of lime	18·37
Phosphate of lime	4·06
Phosphate of magnesia	6·91
Oxide of iron, and loss	1·00

Von Bibra found the amount of carbonates very small, and that of the other salts very variable. Soda-salts greatly preponderate over those of potash, which may even be absent altogether.

Development of hyaline cartilage.—The parts of the embryo which are about to become cartilages are made up at first of the common embryonic cells from which the tissues generally originate. The cell-contents clear up, the nucleus becomes more visible, and the cells, mostly of polygonal outline, appear surrounded by clear lines of pellucid substance, forming as it were a network of bright meshes inclosing them, but in reality consisting of the cohering capsules of the contiguous cells, and constituting all that exists of the matrix at this time. Amyloid matter appears at an early period in the protoplasm of cartilage cells. Rouget found it in the sheep's embryo of two months, both in ossifying cartilage and in the cartilages of the trachea. The subsequent changes consist in enlargement and multiplication of the cells and development of the intermediate matrix. The cells multiply by division. The process is described at page xvii, although all the successive steps there described and represented in the figure (XII.) have not been actually traced. In growing cartilage from the frog-larva, Heidenhain* observed a double (*i. e.* divided) nucleus in some cells, and in certain of these a straight linear partition running across the cell between the two nuclei. This partition was recognised to be double, and doubtless formed by the contiguous thin capsules of two new cells formed by division of the previously single one. It is doubtful how the capsule or secondary cell-wall is produced; whether excreted by the cell which it afterwards incloses, as held by Kölliker, or formed by conversion of a superficial layer of the protoplasm of the cell-body, as taught by Max Schultze, or a primarily independent deposit round the cells. However this may be, there is at first no matrix but what is made up of the simple capsules. In further growth there is a difference according as the cells do or do not undergo frequent division. In the latter case a cell becomes surrounded by many concentric capsules formed in succession; that is, the first capsule is expanded, and the others formed each within its expanding predecessor, so that the cartilage comes to consist of scattered cells, each with a concentric system of capsules, which by means of re-agents may be rendered visible in the neighbourhood of the cells, but further off are inseparably blended into a uniform substance. When, on the other hand, the cells have a tendency to frequent subdivision, the new capsules are produced by the new cells, and are included in and finally blend with those which had belonged to the previous cells, as shown by fig. XII.

The matrix, although thus formed of the capsules, becomes to all appearance homogeneous; but in sections of cartilage that have been exposed to acids and other re-agents, the contour lines of the capsules round cells and cell-groups may be more or less distinctly brought into view. ut whilst admitting that the capsules have a share in the production of the matrix, Kölliker and some other histologists incline to the opinion that part of it is an independent deposit. Heidenhain, however, has found that when thin sections of cartilage are digested for twenty-four hours in water, at from 112° to 122° F., or in diluted nitric acid with chlorate of potash for a greater or less time according to the degree of dilution, the matrix becomes parted or marked off into polygonal areas corresponding to the larger groups of cells, and these again into smaller groups, or single cells, without any intervening substance; the whole matrix thus appearing to be portioned out into segments, each appertaining to a larger or smaller group of cells, and in all probability representing the aggregated capsules belonging to them.

The vital changes which occur in cartilage take place very slowly. Its mode of nutrition has been already referred to; it is subject to absorption, and when a portion is absorbed in disease or removed by the knife, it is not regenerated. Also, when fractured, as sometimes happens with the rib-cartilages, there is no re-union by cartilaginous matter, but the broken surfaces become connected, especially at their circumference, by fibrous or dense areolar tissue, often by a bony clasp. But notwithstanding that normally it is not regenerated, hyaline cartilage occurs in perfectly characteristic form as a morbid product in certain tumours.

ELASTIC OR YELLOW CARTILAGE.

The epiglottis and cornicula of the larynx, the cartilages of the ear and of the Eustachian tube, differ so much from the foregoing, both in intimate

* Studien des Physiologischen Instituts zu Breslau, 2ter Heft, 1863.

structure and outward characters, that they have been included in a class apart, under the name of the "elastic," "yellow," or "spongy" cartilages. These are opaque and somewhat yellow, are more flexible and tough than the ordinary cartilages, and have little tendency to ossify. They are made up of cells and a matrix, but the latter is everywhere pervaded with fibres (fig. XLII.), except sometimes in a little area or narrow zone left round each of the cells. These fibres resist the action of acetic acid; they are in most parts short, straight, and confusedly intersecting each other in all directions, like the filaments in a piece of felt; in such parts the matrix has a rough indistinctly granular look. Here and there the fibres are longer and more fasciculated, but still interlace at short distances. In thin sections the cells readily drop out from the matrix, leaving empty the cavities which they occupied.

Fig. XLII.

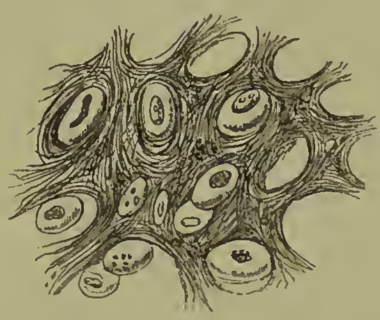


Fig. XLII.—Section of the Epiglottis, magnified 380 diameters (Dr. Baly).

In the fœtus the matrix of elastic cartilage is at first homogeneous and hyaline, and the elastic fibres are then produced in it, quite independently of the cells, and in the same way as in the intercellular substance of growing elastic ligaments.

FIBRO-CARTILAGE.

This is a substance consisting of a mixture of the fibrous and cartilaginous tissues, and so far partaking of the qualities of both. Like hyaline cartilage, it possesses firmness and elasticity, but these properties are united with a much greater degree of flexibility and toughness. It presents itself under various forms, which may be enumerated under the following heads:—

1. *Inter-articular* fibro-cartilages. These are interposed between the moving surfaces of bones, or rather of articular cartilages, in several of the joints. They serve to maintain the apposition of the opposed surfaces in their various motions, to give ease to the gliding movement, and to moderate the effects of great pressure. In the joint of the lower jaw and in that of the clavicle they have the form of round or oval plates, growing thinner towards their centre; in the knee-joint they are curved in form of a sickle, and thinned away towards their concave free edge. In all cases their surfaces are free, while they are fixed by synovial or fibrous membrane at their circumference or extremities. The synovial membrane of the joint, or at least its epithelial coat, is prolonged for a short distance upon these fibro-cartilages, from their attached margin.

2. The articular cavities of bones are sometimes deepened and extended by means of a rim or border of fibro-cartilage. A good example of one of these *circumferential* or *marginal* fibro-cartilages is seen in the hip-joint, attached round the lip of the cotyloid cavity.

3. *Connecting* fibro-cartilages are such as pass between the adjacent surfaces of bones in joints which do not admit of gliding motion, as at the symphysis of the pubes and between the bodies of the vertebræ. They have the general form of disks, and are composed of concentric rings of fibrous tissue with cartilage interposed; the former predominating at the

circumference, the latter increasing towards the centre. The bony surfaces between which they pass are usually encrusted with true cartilage. The modifications which they present in particular instances are described in the special anatomy of the joints.

4. The bony grooves in which tendons of muscles glide are lined with a thin layer of fibro-cartilage. Small nodules of this tissue (*sesamoid fibro-cartilages*) may also be developed in the substance of tendons, of which there is an example in the tendon of the tibialis posticus, where it passes beneath the head of the astragalus. Lastly, fibro-cartilage is sometimes connected with muscular tissue, and gives attachment to muscular fibres, like that which is known to exist at the orifices of the heart.

Fibro-cartilage appears under the microscope to be made up of bundles of fibres, like those of ordinary ligament, with cartilage-cells intermixed; but the proportion of the two elements differs much in the different instances above enumerated. In general the fibrous tissue very greatly predominates, and in some cases, as in the inter-articular laminæ of the knee-joint, it constitutes almost the entire structure. In the intervertebral disks the cartilage-corpuscles are abundant towards the centre of the mass where the cartilaginous tissue prevails, and the substance is softer.

In chemical composition this texture agrees most with ligament, yielding gelatin when boiled.

Its bloodvessels are very few, and, according to Mr. Toynbee,* are confined to the parts that are fibrous. Its vital changes are slow; it is subject to absorption, but much less readily so than bone; hence it is no uncommon thing to find the intervertebral disks entire when the adjacent bodies of the vertebræ have been destroyed by disease. It has not much tendency to ossify.

Little is known concerning the mode of development of fibro-cartilage. Mr. Toynbee concludes from his researches that the cartilaginous element is relatively more abundant at early periods.

BONE, OR OSSEOUS TISSUE.

The bones are the principal organs of support, and the passive instruments of locomotion. Connected together in the skeleton, they form a framework of hard material, which affords attachment to the soft parts, maintains them in their due position, and shelters such as are of delicate structure, giving stability to the whole fabric, and preserving its shape; and the different pieces of the skeleton, being jointed moveably together, serve also as levers for executing the movements of the body.

While substantially consisting of hard matter, bones in the living body are covered with periosteum and filled with marrow; they are also pervaded by vessels for their nutrition.

External configuration.—In their outward forms the bones present much diversity, but have been reduced by anatomists to the following classes:—1. Long or cylindrical, such as the chief bones of the limbs. These consist of a body or shaft, cylindrical or more frequently angular in shape, and two ends or heads, as they are often called, which are usually much thicker than the shaft. The heads, or ends, have smooth surfaces for articulation with neighbouring bones. The shaft is hollow and filled with marrow, by which

* Phil. Trans. 1841.

sufficient magnitude and strength are attained without undue increase of weight. 2. Tabular or flat bones, like the scapula, the ilium, the ribs, the lower jaw, and the bones forming the roof and sides of the skull. Many of these contribute to form the walls of cavities. 3. Short bones, often also called round bones, though most of them rather are angular ; the wrist and tarsus afford examples of these. 4. Irregular or mixed bones, which would, perhaps, be better named "complex :" such as cannot be entirely referred to any of the foregoing classes. These are mostly situated in the median plane, and have a complex but symmetrical figure ; the vertebræ may be taken as instances of them.

The surfaces of bones present various eminences, depressions, and other marks ; and, to designate these in descriptive osteology, certain general terms are employed, of which the following are those most commonly in use.

1. Eminences. To any prominent elevation jutting out from the surface of a bone the term "process" or "apophysis" is applied. It often happens that such a process is originally ossified separately from the rest of the bone, and remains long unconnected with the main body (by osseous union at least) ; in this condition it is named an "epiphysis." In many bones, considerable portions at the extremities or most prominent parts are originally ossified separately as epiphyses. This is the case with the ends of the long bones, and in this instance the shaft is named the "diaphysis."

Processes or apophyses are further designated according to their different forms. A slender, sharp, or pointed eminence is named a "spine" or "spinous process ;" a tubercle, on the other hand, is a blunt prominence ; a "tuberosity" (tuber) is broader in proportion to its elevation, and has a rough uneven surface. The term "crest" is usually applied to the prominent border of a bone, or to an elevation running some way along its surface ; but the latter is more commonly denominated a "line" or "ridge." A "head" (caput, capitulum, or capitellum) is a rounded process, supported on a narrower part named its neck (cervix). A "condyle" has been defined to be an eminence bearing a flattened articular surface ; but this term has been very variously applied by anatomists both ancient and modern.

2. Cavities and depressions of bones. An aperture or perforation in the substance of a bone is named a "foramen." A passage or perforation often runs for some way in the bone, and then it is termed a "canal" or "meatus." On the other hand, it may assume the form of a "fissure," and is named accordingly. A "fossa" is an open excavation or depression on the surface of a bone, or of a part of the skeleton formed by several bones. A fossa may form part of a joint, and be adapted to receive the prominent part of a neighbouring bone ; it is then said to be "glenoid," when shallow ; but a deep excavation, of which the socket for the head of the thigh-bone is an example, is named a "cotyloid" cavity. The meaning of the terms "notch" (incisura), and "groove," or "furrow" (sulcus), is sufficiently plain. "Sinus" and "antrum" are names applied to certain large cavities situated within the bones of the head and opening into the nose.

Physical properties of bone.—Bone has a white colour, with a pink and slightly bluish tint in the living body. Its hardness is well known, but it also possesses a certain degree of toughness and elasticity ; the last property is peculiarly well marked in the ribs. Its specific gravity is from 1·87 to 1·97.

Chemical Composition.—It consists of an earthy and an animal part, intimately combined together; the former gives hardness and rigidity, the latter tenacity, to the osseous tissue.

The earthy part may be obtained separate by calcination. When bones are burned in an open fire, they first become quite black, like a piece of burnt wood, from the charring of their animal matter; but if the fire be continued with free access of air, this matter is entirely consumed, and they are reduced to a white, brittle, chalk-like substance, still preserving their original shape, but with the loss of about a third of their weight. The earthy constituent, therefore, amounts to about two-thirds of the weight of the bone. It consists principally of phosphate of lime, with about a fifth part of carbonate of lime, and much smaller proportions of fluoride of calcium, chloride of sodium, and magnesian salts.

The animal constituent may be freed from the earth, by steeping a bone in diluted hydrochloric acid. By this process the salts of lime are dissolved out, and a tough, flexible substance remains, which, like the earthy part, retains the perfect figure of the original bone in its minutest details; so that the two are evidently combined in the most intimate manner. The animal part is often named the cartilage of bone, but improperly, for it differs entirely from cartilage in structure, as well as in physical properties and chemical nature. It is much softer and much more flexible, and by boiling it is almost wholly resolved into gelatin. It may accordingly be extracted from bones, in form of a jelly, by boiling them for a considerable time, especially under high pressure.

The earthy or saline matter of bone, as already stated, constitutes about two-thirds or 66·7 per cent., and the animal part one-third, or 33·3 per cent.; but from observations made on animals, it appears that the proportion of the several constituents may differ somewhat in different individuals of the same species under apparently similar conditions. The proportion of earthy matter appears to increase for some time after birth, and is considerably greater in adults than in infants; but from the varying conditions of individuals as to health and nutrition in after life, there is as yet no thoroughly comparable series of experiments to determine whether any constant difference exists in old age. Moreover, it is not clearly established that the differences observed depend on the composition of the proper osseous substance; for the larger proportion of animal matter in infancy may be due to the greater vascularity of infantile bones and the difficulty of thoroughly removing the vessels from their pores. The spongy osseous tissue, carefully freed from fat and adhering membranous matter, has been found to contain rather less earth than the compact substance, and in accordance with this result, differences, although on the whole insignificant, have been found in different bones of the skeleton, apparently depending on the relative amount of their compact and spongy tissue. (Rees, Von Bibra, Alphonse Milne-Edwards.) Here again it remains to be shown that the result is not due to differences in the proportion of minute pores and lacunæ, which contain soft matter scarcely separable in such experiments.

Subjoined are the statements of two analyses. The one, by Berzelius, is well known; the other, which nearly agrees with it, was performed by Mr. Middleton, in the laboratory of University College.*

	Berzelius.		Middleton.
Animal matter	33·30	—	33·43
Phosphate of lime	51·04	—	51·11
Carbonate of lime	11·30	—	10·31
Fluoride of calcium	2·00	—	1·99
Magnesia, wholly or partially in the state of phosphate	1·16	—	1·67
Soda and chloride of sodium	1·20	—	1·68

* Philosophical Magazine, vol. xxv. p. 18.

The phosphate of lime is peculiar, and passes in chemistry under the name of the "bone-earth phosphate." It is a tribasic phosphate, consisting probably of 8 equivalents of lime and 1 of water, with 3 eq. of phosphoric acid. Von Bibra and A. Milne-Edwards,* found the proportion of the carbonate of lime to the phosphate, greater in spongy than in compact tissue, and less in infantile bones generally than in those of adults. M.-Edwards considers that carbonate is formed from decomposition of the basic phosphate by the carbonic acid of the blood, and that the proportion must necessarily vary with the state of nutrition; in infancy there is less decomposition and also more rapid elimination of the products of decomposition, hence proportionally less carbonate of lime. The fluoride of calcium is found in larger quantity in fossil than in recent bones—indeed, its presence in the latter was lately denied altogether; but since then, the original statements of Morichini and of Berzelius, to the effect that it exists in recent as well as fossil bones, have been satisfactorily confirmed.

Structure.—On sawing up a bone, it will be seen that it is in some parts dense and close in texture, appearing like ivory; in others open and reticular: and anatomists accordingly distinguish two forms of osseous tissue, viz., the *compact*, and the *spongy* or *cancellated*. On closer examination, however, especially with the aid of a magnifying glass, it will be found that the bony matter is everywhere porous in a greater or less degree, and that the difference between the two varieties of tissue depends on the different amount of solid matter compared with the size and number of the open spaces in each; the cavities being very small in the compact parts of the bone, with much dense matter between them; whilst in the cancellated texture the spaces are large, and the intervening bony partitions thin and slender. There is, accordingly, no abrupt limit between the two,—they pass into one another by degrees, the cavities of the compact tissue widening out, and the reticulations of the cancellated becoming closer as they approach the parts where the transition takes place.

In all bones, the part next the surface consists of compact substance, which forms an outer shell or crust, whilst the spongy texture is contained within. In a long bone, the large round ends are made up of spongy tissue, with only a thin coating of compact substance; in the hollow shaft, on the other hand, the spongy texture is scanty, and the sides are chiefly formed of compact bone, which increases in thickness from the extremities towards the middle, at which point the girth of the bone is least, and the strain on it greatest. In tabular bones, such as those of the skull, the compact tissue forms two plates, or tables as they are called, inclosing between them the spongy texture, which in such bones is usually named *diploe.* The short bones, like the ends of the long, are spongy throughout, save at their surface, where there is a thin crust of compact substance. In the complex or mixed bones, the two substances have the same general relation to each other; but the relative amount of each in different parts, as well as their special arrangement in particular instances, is very various.

On close inspection, the cancellated texture is seen to be formed of slender bars or spicula of bone and thin lamellæ, which meet together and join in a reticular manner, producing an open structure which has been compared to lattice-work (*cancelli*), and hence the name usually applied to it. In this way considerable strength is attained without undue weight, and it may usually be observed that the strongest laminæ run through the structure in those directions in which the bone has naturally to sustain the greatest pressure. The open spaces or areolæ of the bony network com-

* Ann. des Sc. Nat. 4me Série, vol. xiii. 1860.

municate freely together ; in the fresh state they contain marrow or blood-vessels, and give support to these soft parts.

Fig. XLIII.

Fig. XLIII.—A, TRANSVERSE SECTION OF A BONE (ULNA) DEPRIVED OF ITS EARTH BY ACID.

The openings of the Haversian canals seen. Natural size. A small portion is shaded to indicate the part magnified in Fig. B.

B, PART OF THE SECTION A, MAGNIFIED 20 DIAMETERS.

The lines indicating the concentric lamellæ are seen, and among them the corpuscles or lacunæ appear as little dark specks.

The compact tissue is also full of holes ; these, which are very small, are best seen by breaking across the shaft of a long bone near its middle, and examining it with a common magnifying glass. Numerous little round apertures (fig. XLIII. A) may then be seen on the broken surface, which are the openings of short longitudinal passages running in the compact substance, and named the Haversian canals, after Clopton Havers, an English physician and writer of the seventeenth century, who more especially called attention to them. Bloodvessels run in these canals, and the widest of them also contain marrow. They are from $\frac{1}{1000}$th to $\frac{1}{200}$th of an inch in diameter : I have measured some which were no more than $\frac{1}{2000}$th, but these are rare ; the medium size is about $\frac{1}{500}$th. The widest are those nearest the medullary cavity, and they are much smaller towards the circumference of the bone. They are quite short, as may be seen in a longitudinal section, and somewhat crooked or oblique at their ends, where they

freely open into one another, their oblique communications connecting them both longitudinally and laterally. Those also which are next the circumference of the bone, open by minute pores on its external surface, and the innermost ones open widely into the medullary cavity ; so that these short channels collectively form a sort of irregular network of tubes running through the compact tissue, in which the vessels of that tissue are lodged, and through the medium of which these vessels communicate together, not only along the length of the bone, but from its surface to the interior, through the thickness of the shaft. The canals of the compact tissue in the other classes of bones have the same general characters, and for the most part run parallel to the surface.

On viewing a thin transverse section of a long bone with a microscope of moderate power, especially after the earthy part has been removed by acid (fig. XLIII. B), the opening of each Haversian canal appears to be surrounded by a series of concentric rings. This appearance is occasioned by the transverse sections of concentric lamellæ which surround the canals. The rings are not all complete, for here and there one may be seen ending between two others. In some of the sets the rings are nearly circular, in others oval,—differences which seem mostly to depend on the direction in which the canal happens to be cut : the aperture, too, may be in the centre, or more or less to one side, and in the latter case the rings are usually narrower and closer together on the side towards which the aperture deviates. Again, some of the apertures are much lengthened or angular in shape, and the lamellæ surrounding them have a corresponding disposition. Besides the lamellæ surrounding the Haversian canals, there are others disposed conformably with the circumference of the bone (fig. XLIII. B, *a*), and which may therefore be said to be concentric with the medullary canal ; some of these are near the surface of the bone, others run between the Haversian sets, by which they are interrupted in many places. Lastly, in various parts of the section, lines are seen which indicate lamellæ, differing in direction from both of the above-mentioned orders. As to the circumferential laminæ, Messrs. Tomes and De Morgan state that they are by no means so common as is generally supposed ; further, that they are most conspicuous in bones of full growth, in which, consequently, nutritive changes proceed slowly ; and that their presence may be made the means of determining, within certain limits, the age at which a bone has arrived. These authors observe, that in young and rapidly-growing bones the laminæ are frequently seen to have an undulating direction, which they consider as a sign that the tissue is undergoing rapid nutritive changes.

The appearance in a longitudinal section of the bone is in harmony with the account above given : the sections of the lamellæ are seen as straight and parallel lines, running in the longitudinal direction of the bone, except when the section happens to have passed directly or slantingly across a canal ; for wherever this occurs there is seen, as in a transverse section, a series of rings, generally oval and much lengthened on account of the obliquity of the section.

The cancellated texture has essentially the same lamellar structure. The slender bony walls of its little cavities or areolæ are made up of superimposed lamellæ, like those of the Haversian canals (fig. XLIII. B, *b*), only they have fewer lamellæ in proportion to the width of the cavities which they surround ; and, indeed, the relative amount of solid matter and open space constitutes, as already said, the only difference between the two forms of bony tissue ; the intimate structure of the solid substance and the

manner of its disposition round the cavities being essentially the same in both.

Besides the openings of Haversian canals as above described, a transverse section of the compact bone now and then presents vacuities or spaces formed by absorption of the tissue. These are named "Haversian spaces" by Tomes and De Morgan, who first showed that they occur not only in growing bone but at all periods of life. In their primitive condition these cavities are characterised by an irregular or jagged outline, and their formation by absorption is further indicated by their encroaching on the adjacent groups of concentric lamellæ, which have been, as it were, eaten away to a greater or less extent to give place to the new cavity. In another stage the spaces in question are lined by new formed lamellæ, which may as yet be confined to the peripheral part of the vacuity, or may fill it up in a concentric series, leaving a Haversian aperture in the middle, and in fact constituting a system of concentric Haversian lamellæ, interpolated or intruded among those previously existing. The concentric lamellæ, which thus come to occupy a greater or less extent of the area of the cavity, are of course bounded exteriorly by segments of adjoining Haversian lamellæ, which have been more or less cut in upon in the excavation of the space. It has been further observed by Tomes and De Morgan, that vacuities may sometimes be seen which are being filled up at one part by the deposition of lamellæ, whilst they are extending themselves by absorption at another. The Haversian spaces are most numerous in young and growing bones; but, as already stated, they occur also after growth is completed. Their origin and changes will be better understood after the reader has perused the

Fig. XLIV.

Fig. XLIV.—Transverse Section of Compact Tissue (of humerus) magnified about 150 diameters.

Three of the Haversian canals are seen, with their concentric rings; also the corpuscles or lacunæ, with the canaliculi extending from them across the direction of the lamellæ. The Haversian apertures had got filled with débris in grinding down the section, and therefore appear black in the figure, which represents the object as viewed with transmitted light.

account of the growth and development of bone, to which head, indeed, the subject more properly belongs, although it has seemed expedient to introduce it here.

All over the section numerous little dark specks are seen among the lamellæ. These were named the "osseous corpuscles;" but as it is now known that they are in reality minute cavities existing in the bony substance, the name of "lacunæ" has since been more fittingly applied to them. To see the lacunæ properly, however, sections of unsoftened bones must be prepared and ground very thin, and a magnifying power of from 200 to 300 must be employed. Such a section, viewed with transmitted light, has the appearance represented in fig. XLIV. The openings of the Haversian canals are seen with their encircling lamellæ, and among these the corpuscles or lacunæ, which are mostly ranged in a corresponding order, appear as black or dark brown and nearly opaque, oblong spots, with fine dark lines extending from them and causing them to look not unlike little black insects; but when the same section is seen against a dark ground, with the light falling on it (as we usually view an opaque object), the little bodies and lines appear quite white, like figures drawn with chalk on a slate, and the intermediate substance, being transparent, now appears dark.

The lacunæ, as already stated, are minute recesses in the bone, and the lines extending from them are fine pores or tubes named "canaliculi," which issue from their cavity. They present some variety of figure, but in such a section as that represented for the most part appear irregularly fusiform, and lie nearly in the same direction as the lamellæ between which they are situated; or, to speak more correctly, the little cavities are flattened and extended conformably with the lamellæ; for when the bone is cut longitudinally, their sections still appear fusiform and lengthened out in the direction of the lamellæ. The canaliculi, on the other hand, pass across the lamellæ, and they communicate with those proceeding from the next range of lacunæ, so as to connect the little cavities with each other; and thus, since the canaliculi of the most central range open into the Haversian canal, a system of continuous passages is established by these minute tubes and their lacunæ, along which fluids may be conducted from the Haversian canal through its series of surrounding lamellæ; indeed it seems probable that the chief purpose of these minute passages is to convey nutrient fluid from the vascular Haversian canals through the mass of hard bone which lies around and between them. In like manner the canaliculi open into the great medullary canal, and into the cavities of the cancellated texture; for in the thin bony parietes of these cavities lacunæ are contained; they exist, indeed, in all parts of the bony tissue. As first shown by Virchow, each lacuna is occupied by a nucleated cell, or soft corpuscle, which may be separated from the surrounding substance by prolonged maceration of decalcified bone in hydrochloric acid or in solution of potash or soda; and later observers (Rouget, Neumann,) state that they are able to detach also the proper osseous wall of the lacuna and its appertaining canaliculi after decalcification, and to obtain it separate with its included corpuscle. The soft corpuscle or cell has an angular outline corresponding to the shape of the lacuna, but it is not proved that it sends branches along the canaliculi, as Virchow supposed, or that it has a membranous envelope. Nevertheless it can scarcely be doubted that the protoplasm of the nucleated corpuscle takes an important share in the nutritive process in bone, and very probably serves both to modify the nutritive

fluid supplied from the blood and to further its distribution through the lacunar and canalicular system of the bony tissue. Virchow considers that the corpuscles of bone are homologous with those of connective tissue.

To return to the lamellæ. With a little pains thin films may be peeled off in a longitudinal direction from a piece of bone that has been softened in acid. These for the most part consist of several laminæ, as may be seen at the edge, where the different layers are usually torn unequally, and some extend farther than others. Examined in this way, under the microscope, the lamellæ are seen to be perforated with fine apertures placed at very short distances apart. These apertures were described by Deutsch,* but they have not much attracted the notice of succeeding observers; they appear to me to be the transverse sections of the canaliculi already described, and their relative distance and position accord sufficiently with this explanation. According to this view, therefore, the canaliculi might (in a certain sense) be conceived to result from the apposition of a series of perforated plates, the apertures of each plate corresponding to those of the plates contiguous with it; in short, they might be compared to holes bored to some depth in a straight or crooked direction through the leaves of a book, in which case it is plain that the perforations of the adjoining leaves would correspond; it being always understood, however, that the passages thus formed are bounded by proper parietes. The apertures now referred to must be distinguished from larger holes seen in some lamellæ which give passage to the perforating fibres to be mentioned further on.

But the lamellæ have a further structure. To see this the thinnest part of a detached shred or film must be examined, as shown in figs. XLV. and XLVII.; it will then appear plainly that they are made up of transparent fibres, decussating each other in form of an exceedingly fine network. The fibres intersect obliquely, and they seem to coalesce at the points of intersection, for they cannot be teased out from one another; but at the torn edge of the lamella they may often be seen separate for a little way, standing out like the threads of a fringe. Most generally they are straight, as represented in the figure; but they are not always so, for in some parts they assume a curvilinear direction. Acetic or hydrochloric acid causes these fibres to swell up and become indistinct, like the white fibres of connective tissue; care must therefore be taken in their examination that the remains of the decalcifying acid be removed from the tissue, by maceration in water or in solution of an alkaline carbonate. Moreover, the fibro-reticular structure is not equally distinct in all parts where its presence is recognisable; for in some places it is less decidedly marked, as if the fibrillation were incompletely developed—resembling in this respect the areolar and fibrous tissues.

Fig. XLV.

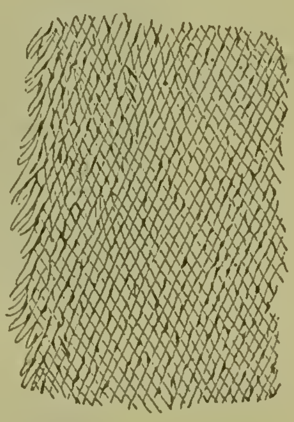


Fig. XLV.—Thin Layer peeled off from a Softened Bone, as it appears under a magnifying power of 400.

This figure, which is intended to represent the reticular structure of a lamella, gives a better idea of the object when held rather farther off than usual from the eye.

In many instances the lamellæ are perforated by fibres, or rather bundles

* De Penitiori Ossium Structura. Wratisl. 1834, p. 17, Fig. 6.

of fibres, which pass through them in a perpendicular, or more or less oblique direction, and, as it were, bolt them together. These *perforating fibres* may be seen, with the aid of the microscope, in a thin transverse slice of a decalcified cylindrical or cranial bone, on pulling asunder the sections of the lamellæ (as in fig. XLVI.). In this way some lamellæ will generally be observed with fibrous processes attached to them (fig. XLVI. *b*) of various lengths, and usually tapering and pointed at their free extremities, but sometimes truncated—probably from having come in the way of the knife. These fibres have obviously been drawn out from the adjacent lamellæ, through several of which they must have penetrated. Sometimes, indeed, indications of perforations may be recognised in the part of the section of bone from which the fibres have been pulled out (fig. XLVI. *c*). The processes in question are thus, so to speak, viewed in profile; but they may frequently also be seen on the flat surface of detached lamellæ, projecting like nails driven perpendicularly or slantingly through a board (fig. XLVII. *a*); whilst the lamellæ at other parts present obvious apertures of considerable size, through which the perforating fibres had passed (fig. XLVII. *b*, *b*).

Fig. XLVI.

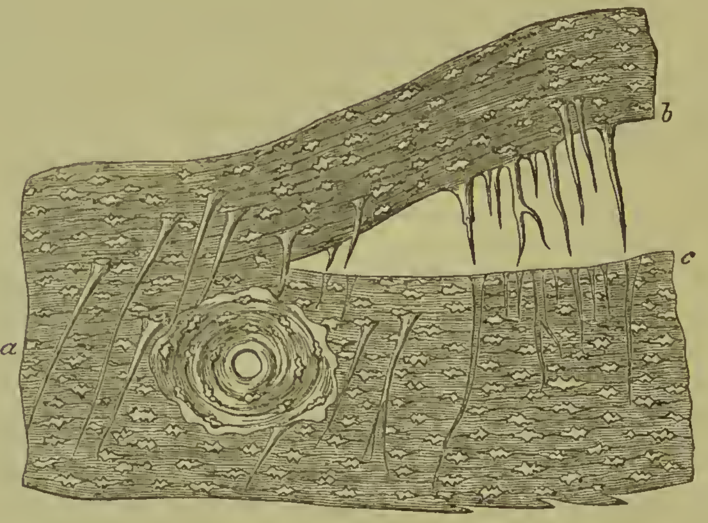


Fig. XLVI.—Magnified View of a Perpendicular Section through the External Table of a Human Parietal Bone, decalcified.

At *a*, perforating fibres in their natural situation; at *b*, others drawn out by separation of the lamellæ; at *c*, the holes or sockets out of which they have been drawn (H. Müller).

These perforating fibres, since first noticed by me, have been shown by Kölliker to exist very generally in the bones of fishes, and to a certain extent in those of amphibia.* I had myself found them abundant in the turtle, and had no doubt of their general existence in vertebrata. The late lamented Henry Müller, of Würzburg, has supplied many details respecting their arrangement in man and mammalia.† Kölliker considers them to be connected with the periosteum, and this, no doubt, is the case with some of them—some of those, for example, which penetrate the external table of the cranial bones; but in cross sections of cylindrical bones they often appear to spring, with their broad ends, from the deeper lamellæ, and taper outwards into fine points, which do not reach the periosteum; although without doubt they must, like the bony layers in which they occur, have been formed by subperiosteal ossification. They are

* Würzburger Naturw. Zeitschr. vol. i. p. 306. † Ibid., vol. i. p. 296.

rarely found, and when present are smaller, in the concentric systems of Haversian lamellæ; in this case they must of course have been formed from the vascular tissue (similar in nature to that under the periosteum) which occupied the Haversian spaces and produced the concentric laminæ. Perforating fibres exist abundantly in the *crusta petrosa* of the teeth.

Fig. XLVII.

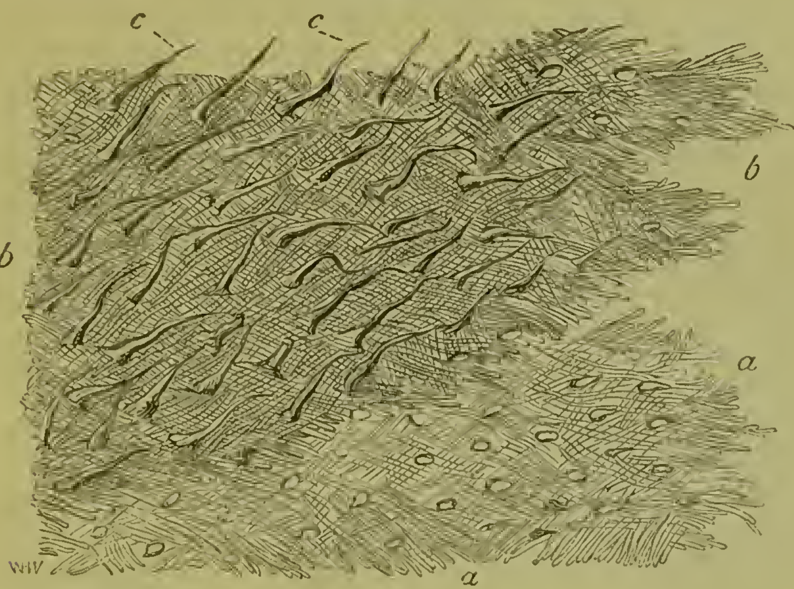


Fig. XLVII.—Lamellæ torn off from a Decalcified Human Parietal Bone at some depth from the Surface.

a, a lamella, showing reticular fibres; *b*, *b*, darker part, where several lamellæ are superposed; *c*, *c*, perforating fibres. Apertures through which perforating fibres had passed, are seen especially in the lower part, *a*, *a*, of the figure. Magnitude as seen under a power of 200, but not drawn to a scale (from a drawing by Dr. Allen Thomson).

The perforating fibres, or rather bundles of fibres, for the most part agree in character with the white fibrous tissue, but some, according to H. Müller, are of the nature of elastic tissue. H. Müller has shown that in some parts the fibres escape calcification, and thus, as they shrink in drying, leave tubes or channels in the dry bone, generally leading from the surface inwardly. In this way he explains the nature and mode of production of the "tubes" described by Tomes and De Morgan as penetrating the bone in certain situations, and conjectured by them to be modified lacunæ.* I at one time believed that these tubes had no relation to the perforating fibres, but I have no doubt of the correctness of Müller's explanation; at the same time I am satisfied that uncalcified fibres, though numerous at particular spots, are by no means so frequent as might be inferred from Müller's account of them, and that the perforating fibres may be said to be generally calcified. Finally, these fibres seem to have no physiological significance: they may be regarded as merely a modification of the mechanical structure of the tissue.

In a thin transverse section of hard bone, the curved lines, or rather bands which represent the cut edges of the lamellæ, generally present, with transmitted light, a dark, granular-like, and a light, transparent, and usually narrower zone. Under a high power of the microscope the former appears thickly dotted over with fine dark points. In a decalcified section the dark part shows a multitude of short bright lines running radially across it, with dark angular particles between them. The lines are probably caused by pores and fine clefts passing through the lamella; the appearance of dark particles seems to me to be produced by the cut ends of the reticulating fibres of which it is made up. A longitudinal section of a cylindrical bone carried across the

* Phil. Traus. 1853, p 116.

lamellæ presents a corresponding appearance, for as the fibres run more or less obliquely to the axis of the bone, they present cut ends in a longitudinal section also.

It thus appears that the animal basis of bone is made up of lamellæ composed of fine reticular fibres ; but interposed among these lamellæ, layers are here and there met with of a different character, viz. :—

1. Strata of amorphous or granular aspect, in which the lacunæ are very conspicuous and regularly arranged, and sometimes appearing as if surrounded by faintly-defined areolæ. These generally incomplete layers often terminate by a scolloped border as if made up of confluent round or oval bodies ; this is indicated also by the occasional occurrence of oval or flattened spheroidal bodies singly or in small groups near the border of these layers, each with a cavity, apparently a lacuna, in the centre. In fact, if the round bodies shown in figure XLVIII. had a central vacuity, they would very well represent the objects here referred to. In some parts the granular substance is obscurely fibrous, and transitions may be observed to the well-marked reticular laminæ. The layers described principally occur, so far as I have been able to observe, near the surface of the compact tissue, and at the circumference of many of the systems of concentric Haversian lamellæ.

2. Irregular layers of rounded bodies, apparently solid and without central cavity or mark, well represented in figure XLVIII., which is after a drawing from nature by Dr. A. Thomson. I have hitherto met with these layers chiefly near the surface of the shaft of long bones, lying among the circumferential laminæ, and, so far as I can observe, forming only part of a circuit. They can occasionally be recognised in a transverse section as short curvilinear bands of peculiar aspect, broader in the middle and thinning away at the ends, appearing here and there between the cut edges of two ordinary circumferential laminæ.

The appearances described under 1 and 2, and especially the last, as represented in fig. XLVIII., suggest the notion of irregular layers of spheroidal bodies, some single, but mostly confluent in groups, adherent to the subjacent surface; and one is especially tempted to this belief by the account given by Gegenbaur * of the deposition of osseous matter in growing bone at certain points in the form of oval or spheroidal globules, which in size and aspect would sufficiently answer to the objects above described. Nevertheless I incline rather to the explanation offered by Professor C. Lovén, of Stockholm, to whom I showed the figure and specimens; viz., that the surface covered apparently with globular bodies, single or in botryoidal groups, is really a cast in relief from a contiguous surface of bone that has been excavated by absorption. It is known that in the growth of a bone absorption occurs at various parts, and is often followed by fresh ossific deposition ; as, for example, in the excavation and subsequent filling up of the Haversian spaces. The absorption in such cases is a healthy process, but the absorbed surface is, as in absorption from disease, eroded or scooped out into sinuous hollows, the larger of which are again carved on the inside into smaller rounded pits. New osseous matter deposited on such a surface fills up its hollows, and when the new layer is detached, it exhibits a raised impression corresponding with them.†

* Jenaische Zeitschrift für Medizin und Naturwissenschaft. Vol. 1. p. 353.

† Two observations which I have had occasion to make favour this explanation. A cross section of a (large) serpent's rib shows an outer and an inner series of concentric lamellæ surrounding the medullary canal, and the inner trenches on the outer by a festooned border such as often bounds a series of Haversian rings. Now, in the decalcified rib, it is easy to peel off the inner from the outer layers, and the detached surface of the former shows a number of oval eminences, some with one, others with two, three, or more lacunæ in their substance ; whilst what was the contiguous surface of the outer layers has excavations that correspond. Again, in the grinding tooth of the horse, the surface of the

Ossified cartilage is found on the articular ends of adult bones, lying underneath the natural cartilage of the joint, both in the moveable articu-

Fig. XLVIII.

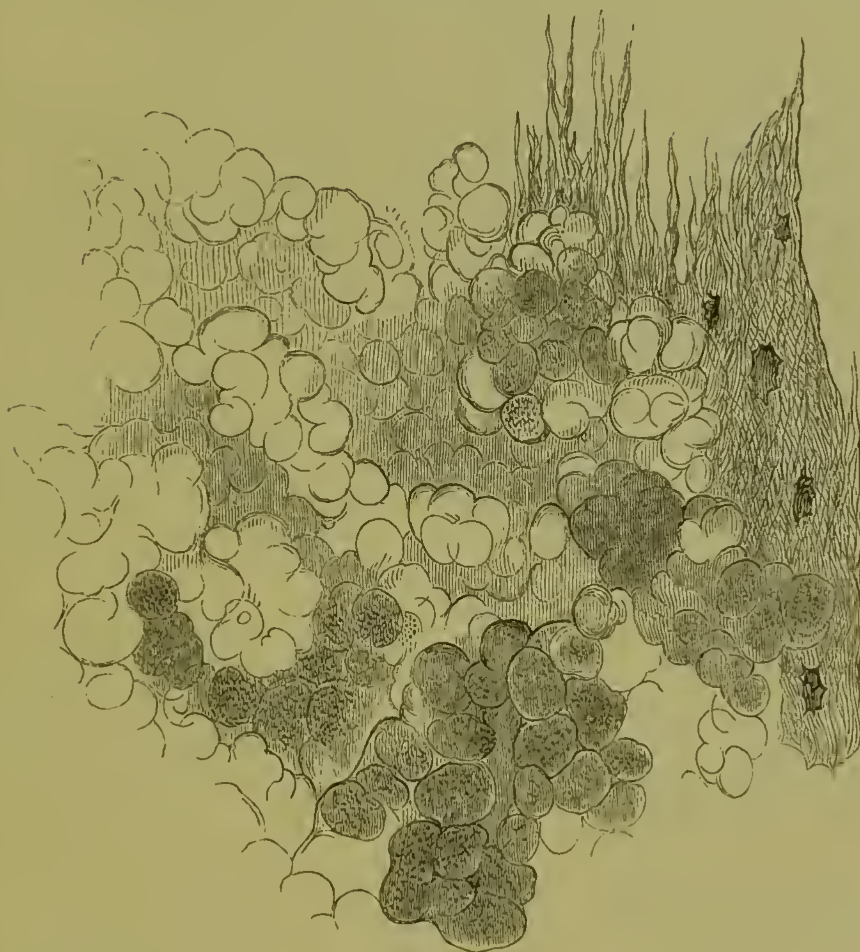


Fig. XLVIII.—Portion of a Nodulated Layer of Bone-Tissue from near the surface of the Shaft of a Decalcified Humerus.

At one side shreds of fibrous lamellæ are seen in the figure. Magnified 300 diameters.

lations and in symphyses, and is in fact the deeper part of the cartilage which has been encroached upon by the calcifying process. The animal basis is here, however, of a totally different nature from that of the bone

crusta petrosa which is contiguous to the dentine or to the enamel, is marked over with spheroidal bodies having, in decalcified specimens, very much the appearance represented in Fig. XLVIII., but most of them with one or more lacuna-like cavities within. They look very like distinct globules, and have been described by Czermak as calcified cells containing lacunæ; but on carefully viewing the decalcified layer in profile-sections and otherwise, I am led to the conclusion that they are mammillary elevations of the surface, continuous by their (sometimes contracted) bases with the general substance. The enamel is destroyed in the decalcification, but the surface of the dentine of the cervix and root from which the mammillated layer of crusta petrosa has been detached, is found to be excavated in a manner to correspond with it; an arrangement well calculated to secure their mutual connection.

beneath; for, when the earthy matter is extracted by means of an acid, the tissue which remains has all the characters of cartilage.

As to the mode in which the earthy matter is connected with the animal substance, we know that the combination is very intimate, but the manner in which it is effected is not fully understood; probably there is a chemical union between the collagenous matter and the earthy salts.

The periosteum, as already stated, is a fibrous membrane which covers the bones externally. It adheres to them very firmly, and invests every part of their surface, except where they are covered with cartilage or connected to other bones by fibro-cartilage. According to Kölliker it is composed of two different layers; the outer, consisting of white fibres, and containing occasional fat-cells, is the means of supporting numerous blood-vessels destined for the bone, which ramify in the membrane, and at length send their minute branches into the Haversian canals of the compact substance, accompanied by processes of filamentous tissue derived from, or at least continuous with, the periosteum. The inner layer is made up of elastic fibres; and frequently presents the appearance of several distinct strata of "elastic membrane." Fine nervous filaments spread out in the periosteum; they are chiefly associated with the arteries, and for the most part destined for the subjacent bone; but some are for the membrane itself.

The chief use of this membrane is evidently to support the vessels going to the bone, and afford them a bed in which they may subdivide into fine branches, and so enter the dense tissue at numerous points. Hence, when the periosteum is stripped off at any part, there is great risk that the denuded portion of the bone will die and exfoliate. The periosteum also contributes to give firmer hold to the tendons and ligaments where they are fixed to bones; indeed, these fibrous structures become continuous and incorporated with it at their attachment.

The *marrow* (medulla ossium) is lodged in the interior of the bones; it fills up the hollow shaft of long bones and occupies the cavities of the cancellated structure; it extends also into the Haversian canals—at least into the larger ones—along with the vessels. Like ordinary adipose tissue, it consists of vesicles containing fat, with blood-vessels distributed to them. A fine layer of a highly vascular areolar tissue lines the medullary canal, as well as the smaller cavities which contain marrow; this has been named the medullary membrane, internal periosteum, or endosteum; but it cannot be detached as a continuous membrane. Its vessels partly supply the contiguous osseous substance, and partly proceed to the clusters of adipose vesicles, among which there is but very little connective tissue, in consequence perhaps of their being contained and supported by bone.

The marrow differs considerably in different situations. Within the shaft of the long bones it is of a yellow colour, and contains, in 100 parts, 96 of fat, 1 of connective tissue, and 3 of water. In short bones, and in the cancellated ends of long bones, but especially in the cranial diploe, the bodies of the vertebræ, the sternum, and the ribs, it is red or reddish in colour, of more fluid consistence, and with very few fat cells. That from the diploe consists of 75 parts of water and 25 of solid matters, which are chiefly albumen, fibrin, extractive and salts, with mere traces of fat. While, however, the fat cells are scanty in the red-coloured marrow, it contains minute, roundish nucleated cells—the proper marrow-cells of Kölliker. These, which include no fat, correspond in character with the cells found in the articular ends of long bones affected with hyperæmia; they occur normally in the cranial bones, ver-

tebræ, and sternum, and in variable number in the scapula, the innominate, and facial bones.

The marrow serves the same general purposes in the economy as ordinary fat. Placed within the bones, which are made hollow for the sake of lightness, it serves as a light and soft material to fill up their cavities and support their vessels. In birds, for the sake of still further lightening their skeleton, the larger bones, instead of being filled with marrow, contain air, which passes into them from the lungs by openings at their extremities. Even in man there are certain hollow bones of the cranium and face which are naturally filled with air. The cavities of these bones are named sinuses; they open into the adjoining air-passages, and are lined with a prolongation of the mucous membrane, underneath which is a thin periosteum.

The bones do not at first contain fatty marrow; in the fœtus their cavities are filled with a transparent reddish fluid, like bloody serum, only more consistent and tenacious, with granular marrow cells. In dropsical subjects also, the marrow, like the rest of the fat, is consumed to a greater or less extent, its place being occupied by a serous fluid.

Blood-vessels.—The bones are well supplied with blood-vessels. A network of periosteal vessels covers their outward surface, others penetrate to the cavities of the spongy part and the medullary canal, on the sides of which they ramify, and fine vessels, deprived of their muscular coat, run through all parts of the compact tissue in the Haversian canals. The sides of these internal cavities and canals make up together a large extent of inward surface on which vessels are spread. The nutritious fluid conveyed by these vessels no doubt escapes through their coats and permeates the surrounding dense bone interposed between the vascular canals; and it seems highly probable that the system of lacunæ and communicating canaliculi, already described, is a provision for conducting the exuded fluid through the hard mass. When a bone is macerated, its vessels and membranes are destroyed, whilst the intermediate true bony matter, being of an incorruptible and persistent nature, remains; a process which, for obvious reasons, cannot be effected with the soft tissues of the body.

The vessels of bone may be recognised while it is yet fresh by the colour of the blood contained in them; but they are rendered much more conspicuous by injecting a limb with size and vermilion, depriving the bones of their earth by means of an acid, and then drying them and putting them into oil of turpentine, by which process the osseous tissue is rendered transparent whilst the injected matter in the vessels retains its red colour and opacity. Numberless small vessels derived from the periosteum, as already mentioned, pass along the Haversian canals in the compact substance. These are both arterial and venous, but, according to Todd and Bowman, the two kinds of vessels occupy distinct passages; and the veins, which are the larger, present, at irregular intervals, pouch-like dilatations calculated to serve as reservoirs for the blood, and to delay its escape from the tissue. Arteries, of larger size but fewer in number, proceed to the cancellated texture. In the long bones numerous apertures may be seen at the ends, near the articular surfaces; some of these give passage to the arteries referred to, but the greater number, as well as the larger of them, are for the veins of the cancellated texture, which run separately from the arteries. Lastly, a considerable artery goes to the marrow in the central part of the bone; in the long bones this medullary artery, often, but improperly, called "the nutritious artery," passes into the medullary canal, near the middle of the shaft, by a hole running obliquely through the compact substance. The vessel, which is accompanied by one or two veins, then sends branches upwards and downwards to the marrow and medullary membrane in the

central cavity and the adjoining Haversian canals. Its ramifications anastomose with the arteries of the compact and cancellated structure ; indeed, there is a free communication between the finest branches of all the vessels which proceed to the bone, and there is no strictly defined limit between the parts supplied by each. In the thigh-bone there are two medullary arteries entering at different points.

The veins of the cancellated texture are peculiar and deserve special notice. They are large and numerous, and run separately from the arteries. Their arrangement is best known in the bones of the skull, where, being lodged in the diploe or spongy texture between the outer and inner compact tables, they have received the name of the diploic veins. They run in canals formed in the cancellated structure, the sides of which are constructed of a thin lamella of bone, perforated here and there for the admission of branches from among the adjoining cancelli. The veins, being thus inclosed and supported by the hard structure, have exceedingly thin coats. They issue from the bone by special apertures of large size. A similar arrangement is seen in the bodies of the vertebræ, from whence the veins come out by large openings on the posterior surface.

The lymphatics of the bones are but little known ; still, there is evidence of their existence, for, independently of the authority of Mascagni (which is of less value in this particular instance, inasmuch as he does not state expressly that he injected the vessels which he took for the lymphatics of bone), we have the testimony of Cruikshank, who injected lymphatics coming out of the body of one of the dorsal vertebræ, in the substance of which he also saw them ramifying.*

Fine nerves have been seen passing into the medullary canal of some of the long bones along with the artery, and following its ramifications, but their ultimate distribution is doubtful ; and Kölliker describes fine nervous filaments as entering with the other arteries of the bone to the spongy and compact tissue. As far, however, as can be judged from observations on man and experiments on the lower animals, the bones, as well as their investing periosteum, are scarcely if at all sensible in the healthy condition, although they are painfully so when inflamed.

Some hold that the same is true of the marrow, or rather the medullary membrane ; others, among whom are Duverney and Bichat, affirm, on the contrary, that the medullary tissue is sensible. They state that, on sawing through the bone of a living animal, and irritating the medullary membrane by passing a probe up the cavity, or by injecting an acrid fluid, very unequivocal signs of pain will be manifested. Beclard, who affirms the same fact, points out a circumstance which may so far account for the result occasionally turning out differently,—namely, that when the bone happens to be sawn through above the entrance of the medullary artery, the nerves going along with that vessel are divided, and the marrow consequently rendered insensible, as happens with any other sensible part when its nerves are cut.

Formation and growth of bone.—The foundation of the skeleton is laid at a very early period, for among the parts that appear soonest in the embryo, we distinguish the rudiments of the vertebræ and base of the skull, which afterwards form the great median column to which the other parts of the bony fabric are appended. But it is by their outward form and situation only, that the parts representing the future bones are then to be recognised ; for at that early period they do not differ materially in substance from the other structures of the embryo, being, like these, made up of granular

* Anatomy of the Absorbing Vessels, 1790, p. 198.

corpuscles or elementary cells, united together by a soft amorphous matter. Very soon, however, they become cartilaginous, and ossification in due time beginning in the cartilage and continuing to spread from one or from several points, the bone is at length completed.

But while it is true with respect to the bones generally that their ossification commences in cartilage, it is not so in every instance. The tabular bones, forming the roof of the skull, may be adduced as a decided example to the contrary; in these the ossification goes on in a membranous tissue quite different in its nature from cartilage;* and even in the long bones, in which ossification undoubtedly commences and to a certain extent proceeds in cartilage, it will be afterwards shown that there is much less of the increment of the bone really owing to that mode of ossification than has, till lately, been generally believed. It is necessary, therefore, to distinguish two species or modes of ossification, which for the sake of brevity may be called the *intramembranous* and the *intracartilaginous*.

Fig. XLIX.

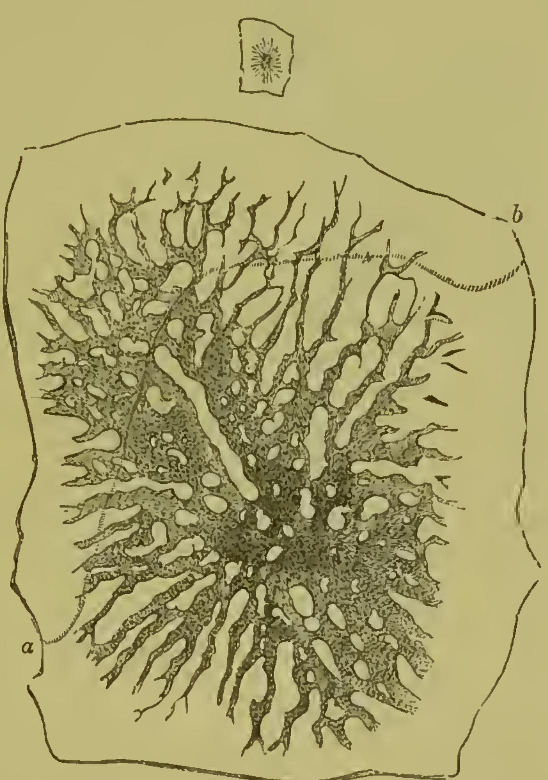


Fig. XLIX.—Parietal Bone of an Embryo Sheep. Size of the Embryo, $2\frac{1}{2}$ inches.

The small upper figure represents the bone of the natural size, the larger figure is magnified about 12 diameters. The curved line, *a*, *b*, marks the height to which the subjacent cartilaginous lamella extended. A few insulated particles of bone are seen near the circumference, an appearance which is quite common at this stage.

Ossification in membrane.—The tabular bones of the cranium, as already said, afford an example of this mode of ossification. The base of the skull in the embryo is cartilaginous; but in the roof, that is to say, the part comprehending the parietal, the upper and greater part of the frontal, and a certain portion of the occipital bones, we find (except where there happen to be commencing muscular fibres) only the integuments, the dura mater, and an intermediate membranous layer, which differs from cartilage in its intimate structure as well as in its more obvious characters, and in which the ossification proceeds.

The commencing ossification of the parietal bone, which may be selected as an example, appears to the naked eye in form of a net-work in which the little bars or spicula of bone run in various directions, and meet each other at short distances. By and by the ossified part, becoming

* This fact was pointed out and insisted on by Dr. Nesbitt, who distinguishes the two different modes of ossification, and so far his views are quite correct.—See his human Osteogeny, Lond. 1736.

extended, gets thicker and closer in texture, especially towards the centre, and the larger bony spicula which now appear, run out in radiating lines to the circumference. The ossification continues thus to spread and consolidate until the parietal meets the neighbouring bones, with which it is at length united by suture.

The figure (XLIX.) represents the parietal bone of an embryo sheep about two inches and a half long, and shows the character of the ossification as it appears when the object is magnified about twelve diameters. The bone is formed in membrane as in the human fœtus, but a thin plate of cartilage rises up on its inside from the base of the skull. The ossification, however, is decidedly unconnected with the cartilage, and goes on in a membrane lying outside of it. The cartilaginous plate is not represented in the figure, but a dotted curve-line, *a*, *b*, near the top, marks the height to which it reached, and from this it will be seen that the ossification extended beyond the cartilage. In the region of the frontal bone the cartilage does not even rise so high. In both cases its limit is well defined, and under the microscope it presents a decided contrast to the adjacent membrane.

When further examined with a higher magnifying power, the tissue or membrane in which the ossification is proceeding, appears to be made up of fibres and granular corpuscles, with a soft amorphous or faintly granular uniting matter, and, in point of structure might not unaptly be compared to connective tissue in an early stage of development. The corpuscles are large, mostly two or three times the size of blood corpuscles; their substance is granular in character, and, especially in specimens preserved in spirit, usually hides the nucleus. They are densely packed all over the area of ossification, covering the bony spicula, and filling up their interstices; so that, to bring the growing parts into view, the corpuscles must be washed away with a hair pencil, or removed by short immersion of the specimen in weak solution of soda.

On observing more closely the points of the growing osseous rays at the circumference of the bone, where they shoot out into the soft tissue, it will be seen that the portion of them already calcified is granular and rather dark in appearance (fig. L., *a*, *b*, *e*), but that this character is gradually lost as they are traced further outwards in the membrane, in which they are prolonged for a little way in form of soft and pliant bundles of transparent fibres (fig. L., *f*). Further inwards, where the slender rods or bars of bone are already in great part hard, their calcified substance is coated over (although unequally) with transparent and as yet soft and imperfectly calcified matter, by which they grow in thickness; and this ossifying substance spreads out at their sides, and encroaches on the intervening space, in form of a bright trellis-work (fig. L., *d*), thin towards its outer limit, and there composed of fine fasciculi, but denser and coarser nearer the bone, where the trabeculæ are thick and round, and already granular from commencing earthy impregnation.* The interstices of this mesh-work are in some parts occupied by one or more of the corpuscles, but at other parts they are reduced to short narrow clefts or mere pores. The appearance which I have endeavoured to describe is especially well seen at those places where a cross bridge of bone is being formed between two long spicula (as at *e*); we may there distinguish the clear

* A notion of this appearance may also be obtained from Fig. LVIII., page cxiii., which represents intramembranous ossification advancing under the periosteum of a long bone. From *a* to *c* is the ossifying trellis-work, but coarser than in the early cranial bone. From *a* to *b* is the part already impregnated with earthy deposit, which is encroaching on the part *b*, *c*, as yet soft and pellucid.

soft fibres or trabeculæ which have already stretched across the interval ; and the darkish granular opacity indicating the earthy deposit (a, a') may be perceived advancing into them and shading off gradually into their pellucid substance without a precise limit. This soft transparent matter, which becomes ossified, may, wherever it occurs, be distinguished by the name of "osteogenic substance," as proposed by H. Müller, or simply of "osteogen." It is or becomes fibrous in intimate structure, and for the most part finely reticular, like the decalcified bone itself, but must not be confounded with fibres which may pre-exist in the membranous tissue in which the bone is growing.

The granular corpuscles or cells everywhere cover in a dense layer the osteogenic substance, and lie in its meshes ; most probably they yield or excrete that substance, and hence it has been proposed to call them "osteoblasts." On this view the process might be compared to the production, by cells, of the matrix of cartilage and the intercellular fibrillating substance in growing connective tissue ; also to the excretion of membranous, cuticular, and other deposits by cells, and layers of cells, long since pointed out by Kölliker.

But some of the granular cells are involved in the ossifying matrix, and eventually inclosed in lacunæ. Single cells may accordingly be seen partially sunk in the recent osteogenic deposit, which then gradually grows over them and buries them in its substance ; and the cavity in which the corpuscle is thus inclosed becomes a lacuna.

Some observers state that when such a corpuscle is as yet but half sunk in the growing substance, processes may be seen passing from the imbedded side into fine clefts of the matrix, which close in around them and become the canaliculi ; and that as the inclosure of the corpuscle is completed, canaliculi are in like manner formed in the rest of its circumference. It is also supposed that the canaliculi are afterwards extended by absorption, so as to anastomose with those of neighbouring lacunæ. But from all I can see of the process, it seems more probable that whilst the ossific matter closes in around the corpuscle

Fig. L.

Fig. L.—The Growing End of a Spiculum from the Parietal Bone of an Embryo Sheep at about the same period of advancement as in Fig. XLIX. ; magnified 150 diameters, but drawn under a power of 350 diameters.

a, b, c, and a', parts already calcified ; d, d, irregular network of soft and pellucid osteogenic substance, on which the calcification is encroaching ; a, e, a', a connecting bar or bridge still soft at e, but calcified at a and a' ; f, extremity formed of bundles of soft osteogenic fibres. N.B. The structure represented was covered over and hidden by granular corpuscles which have been removed. In the calcified part, a, b, c, superficial excavations are seen which are probably commencing or incomplete lacunæ, from which the corpuscles have been washed out. From a drawing by Mr. J. Marshall, F.R.S.

and forms the lacuna, the canaliculi and their communications may be merely channels left as vacuities in the osseous deposit, into which the processes of the now stellate corpuscle pass but a short way.

As the bone extends in circumference, it also increases in thickness ; the vacuities between the bony spicula become narrowed or disappear, and at a more advanced period the tabular bones of the cranium are tolerably compact towards the centre, although their edges are still formed of slender radiating processes. At this time also numerous furrows are grooved on the surface of the bone in a similar radiating manner, and towards the centre these are continued into complete tubes or canals in the older and denser part, which run in the same direction. The canals, as well as the grooves, which become converted into canals, contain blood-vessels supported by processes of the investing membrane, and are lined with granular cells, which deposit concentric layers of bone inside these channels ; and when thus surrounded with concentric laminæ, these tubular cavities are in fact the Haversian canals.

Fig. LI.

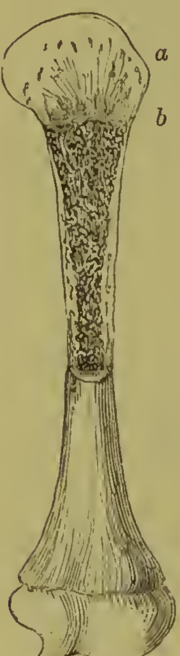


Fig. LI.—Humerus of a Fœtus, natural size.

The upper half is divided longitudinally. *a*, cartilage, *b*, bone, which terminates towards the cartilage by a slightly convex surface.

I may here observe that in earlier stages, such as that shown in fig. XLIX., vessels may be seen in the soft tissue, some twice or three times the size of a blood-capillary, others considerably more, but all with only a homogeneous coat with cells upon it here and there, and without a muscular layer.

Ossification in cartilage.—It has already been stated that in by far the greater number of bones, the primitive soft cellular matter of which they originally consist is very quickly succeeded by cartilage, in which the ossification begins. One of the long bones taken from a very small embryo, just before ossification has commenced in it, is observed to be distinctly cartilaginous. In the tibia of a sheep, for example, at a time when the whole embryo is not more than an inch and a quarter in length, we can plainly see that the substance consists of cartilage-cells imbedded in a pellucid matrix. These cells, which can scarcely be said to be collected into groups, are much larger in the middle part of the shaft where ossification afterwards commences, and there also they are mostly placed with their long diameter across the direction of the bone : towards the ends they are much smaller and closer together, and the cartilage there is less transparent. As it enlarges the cartilage acquires firmer consistence ; it represents in figure the future bone, though of course much smaller in size, and it is surrounded with a fibrous membrane or perichondrium, the future periosteum. Vessels ramify in this membrane, but none are seen in the cartilage until ossification begins.

In a long bone the ossification commences in the middle and proceeds towards the ends, which remain long cartilaginous, as represented in fig. LI. At length separate points of ossification appear in them, and form epiphyses, which at last are joined to the body of the bone.

The new-formed osseous tissue is red and obviously vascular, and blood-vessels extend a little way beyond it into the adjoining part of the cartilage.

In a long bone these precursory vessels are seen at either end of the ossified portion of the shaft, forming a red zone in that part of the cartilage into which the ossification is advancing. The vessels are lodged in excavations or branching canals in the cartilage, (fig. LI. *a*,) which also contain granular corpuscles and soft matter. Other vascular canals enter the cartilage from its outer surface, and conduct vessels into it directly from the perichondrium; at least, this may be seen when the ossification approaches near to the ends of the bones.

Dr. Baly has observed that in a transverse section of the ossifying cartilage, its cells appear arranged in radiating lines round the sections of the vascular canals; * and I may also remark that in many of these radiating groups the cells successively diminish in size towards the centre, that is, as they approach the canal. The canals which enter from the surface of the cartilage are probably formed by processes from the vascular subperichondrial tissue, which, excavating the canals by absorption, thus extend themselves through the mass of cartilage; and as the perichondrium affords material for the growth of the cartilage at the surface, so these vascular processes probably yield matter for the multiplication of the cells in the interior of the mass. The canals which pass into the cartilage from the ossified part are, in like manner, most probably formed by processes of the subperiosteal tissue which pierce the bone and extend through the medullary cavities within it to the cartilage, into which they penetrate for a short way beyond the advancing limit of ossification.

To examine the process more minutely, let an ossifying bone be divided lengthwise, as in fig. LI., and then from the surface of the section (as at *a*, *b*) take off a thin slice of cartilage, including a very little of the ossified part, and examine it with the microscope. Such a view, seen with a low power, is shown in fig. LII. The cartilage at a distance from the surface of the ossified part has its cells uniformly disseminated in the matrix, (as at *a*, where it appears in the figure as if granular,) but at and near to the limit where the ossification is encroaching upon it, the cells are gathered into rows or oblong groups, between which the transparent matrix appears in form of clear longitudinal lines (often obscurely striated) obliquely intersecting each other (*b*). Tomes and De Morgan state that these rows are formed by segmentation of the cartilage cells transversely to the line of ossific advance. Turning now to the newly-formed bone (*c*), which from its dark opaque aspect contrasts strongly with the cartilage, and tracing it towards their mutual boundary, we see plainly the dark lines of ossification shooting up into the clear spaces of the cartilage between the groups of corpuscles. The earthy deposit, in fact, proceeds through the matrix, and affects also those parts of the cartilage-capsules which form the circumference of a group, so that the new osseous substance forms in the first instance oblong areolæ or loculi, which inclose the groups of cells. This is further illustrated by a thin transverse section, carried nearly parallel to the ossifying surface, and partly encroaching on it, so as to take off a little of the bone along with the cartilage, as represented in fig. LIII. In this view we see, at one part, the dark and nearly circular sections of the newly-formed osseous areolæ; at another, sections of the rows of cartilage cells with the clear matrix between and around them, and into this the dark ossification is advancing.

On using a higher power, as in figs. LIV. and LV., it will be seen that the cells forming the groups are placed with their long diameter transversely, as if they had been flattened and piled upon one another; but in the immediate vicinity of the bone they become greatly enlarged and more rounded. In most of them the outline of the capsule is distinct from that of the mass within. As to the matter they

* Müller's Physiology, plate I., fig. 16.

contain, in some it is a pellucid substance strongly refracting the light, and nearly filling the capsule; in others it is faintly granular and light like ground glass, and has a well-defined outline, and in these there is a very distinct nucleus, varying much in size in different cells, but always most regularly circular, and inclosing one or more nucleoli; lastly, a good many cells may be seen, in which the contained mass or cell-body has shrunk and does not nearly fill the capsule, and then it is usually coarsely granular or grumous, with an uneven, and in some, a jagged outline.

Fig. LII.

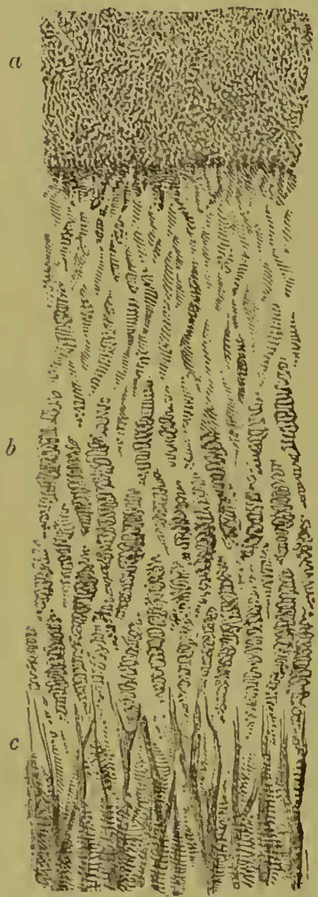


Fig. LIII.

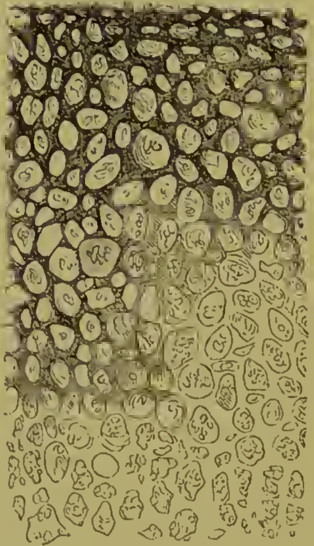


Fig. LII.—Thin Longitudinal Section of Ossifying Cartilage from the Humerus of a Fœtal Sheep.

a, cartilage cells uniformly diffused; *b*, cells nearer the boundary of the ossification, collected into piles and inclosed in oblong areolæ of the clear matrix; *c*, dark lines of ossification extending into the matrix and forming the primary bony areolæ. Magnified about 70 diameters.

Fig. LIII.—Transverse Section of the Ossifying Cartilage represented in Fig. LII.,

Made a little above *c*, along the surface of ossification, and including part of the new bone, magnified 70 diameters. The circular sections of the groups of cells and of the osseous areolæ are seen; and the dark bone extending into the clear intercellular matrix.

It thus appears that the bony tissue, as it advances into the cartilage, has at first a sort of alveolar structure, made up of fusiform *areolæ* or short tubular cavities, with thin parietes, which are formed by calcifi-

cation of the matrix and partial calcification of the capsules of the cartilage-cells. But this condition, which differs from that of perfect bone, is only transitory, and at a short distance below the ossifying surface we see a change taking place in the newly-formed tissue; the structure becomes more open, the original cartilage cells disappear from its interstices, and the medullary spaces, with their lamellated parietes, as in the permanent cancellated tissue, begin to be formed. This, which is the next step of the process, takes place in the following manner:—The *primary areolæ* of the bone above described open into one another both laterally and longitudinally by absorption of their intermediate walls, and by their confluence give rise to the larger or *secondary cavities*, the *medullary spaces* of H. Müller, which succeed them lower down. This is shown in a longitudinal section in fig. LV., and in transverse section in fig. LVI., A, which represents a thin section made almost immediately below the surface of ossification, and in which the primary cavities are seen to have coalesced into larger ones. A transverse section somewhat lower down, (fig. LVI., B,) shows that they go on enlarging by further absorption and coalescence, and that their sides are thickened by layers of new bone; this soon begins to be deposited, (fig. LV., *b*, *b*, in longitudinal, and LVI., A, in cross section) and goes on increasing, (fig. LVI., B). In the meantime the cartilage cells have disappeared, and the bony cavities are filled with soft matter, in which there are a few fibres and numerous granular corpuscles resembling those seen in the intramembranous ossification (*d*, fig. LV.); there are also many blood-vessels. In the end, some of the enlarged cavities and open structure remain to form the cancellated tissue, but much of this structure is afterwards removed by absorption, to give place to the medullary canal of the shaft. In many of these cavities the walls of the coalesced primary areolæ may long be distinguished, like little arches, forming by their union a sort of festooned outline, within which the new bony laminæ are situated.

Fig. LIV.

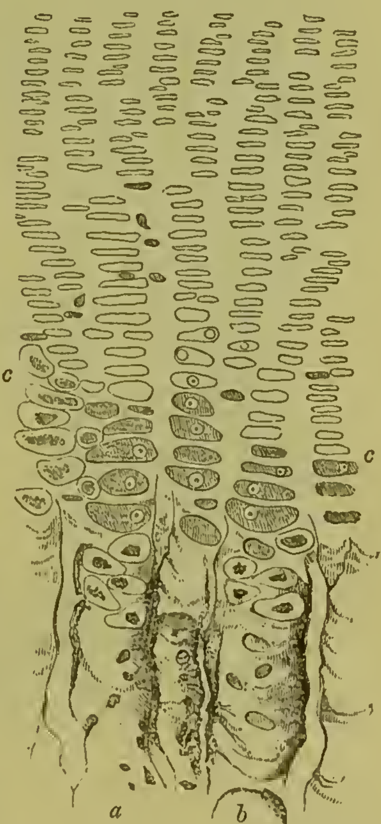


Fig. LIV.—Small Portion of a Section similar to that in Fig. LII., more highly magnified (about 140 diameters).

a, *b*, two of the new-formed osseous tubes or areolæ, with a few cartilage cells and granular corpuscles lying in them; *c*, *c*, cartilage cells near the ossifying surface, exhibiting the appearances described in the text.

The primary osseous matter forming the original thin walls of the areolæ, and produced by calcification of the cartilaginous matrix, is decidedly granular, and has a dark appearance; the subsequent or *secondary deposit* on the other hand is quite transparent, and of an uniform, homogeneous aspect. This secondary deposit begins to cover the granular bone a very short distance (about $\frac{1}{80}$th of an inch) below the surface of ossification, and, as already stated, increases in thickness further down. The lacunæ first appear in this deposit; there are none in the primary granular bone. The cartilage cells do not become calcified. According to H. Müller the capsules

are opened by absorption, and the granular bodies contained within them (*i. e.* the proper cell-bodies) produce by fissiparous multiplication the granular osteoblastic cells which succeed them. On the other hand, Lovén* has suggested, and, as I think, with more probability, that the osteoblastic corpuscles properly belong to the vascular processes of the subperiosteal tissue, which, as already stated, penetrate the new-formed bone and spread throughout its cavernulated structure. The excavation and removal of the cartilage, as well as the partial absorption of the walls of the bony cavities, is no doubt effected by this tissue, and the abundant osteoblastic cells which appear in it are most probably derived by descent from similar cells equally abundant beneath the periosteum. The cells or corpuscles in question, in whatever way produced, are disposed in a layer or layers upon the walls of the secondary or medullary spaces, in immediate contact with the new osteogenic deposit, which here, as in the intra-membranous ossification, they probably secrete. Here too the osteogenic substance is finely reticular, and retains that character when calcified; for the secondary bony deposit is formed in layers made up of finely reticulating fibres, like the lamellæ of perfect bone shown in fig. XLV. On a careful inspection, and with a certain adjustment of the light, fine striæ may be seen in many parts indicating the obliquely decussating fibres of the new-formed laminæ. The structure in some measure reminds us of the secondary deposit inside the oblong cells of the wood of coniferous trees, in which the ligneous matter is arranged in fibres, or rather in fine lines, running obliquely round the wall of the cell and crossing one another in alternate layers.

Fig. LV.

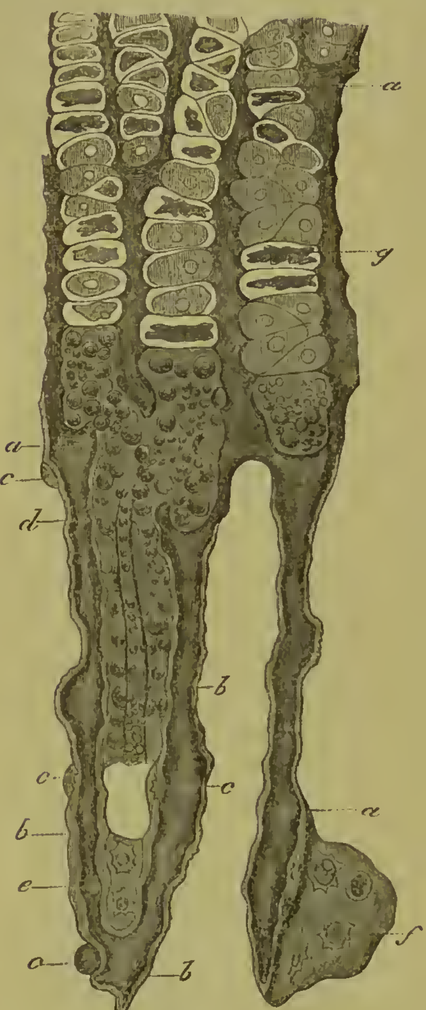


Fig. LV.—Thin Longitudinal Section of the Growing End of the Shaft of the Metatarsal Bone of a Slink Calf, magnified.

The upper part of the figure shows four groups of cartilage cells, with calcified matrix between them forming the walls of four primary areolæ filled as yet by the original cartilage cells, except at the lower part where these are replaced by granular corpuscles. Lower down are two oblong spaces (secondary or medullary cavities); one, indicated by *d*, is nearly filled by granular corpuscles and vessels, the other is vacant. The walls of these spaces are beginning to be lined with secondary osseous deposit, shown in the figure as a lighter layer, *b*, *b*, and *b*; *c*, *c*, and *c*, are corpuscles about to be imbedded in the ossifying substance and inclosed in laminæ; *g*, a cartilage cell of which the body has shrunk from the inside of the capsule. After H. Müller and Kölliker.

The lacunæ are formed, as described in the intra-membranous ossification, by some of the granular corpuscles becoming imbedded in the osteogenic substance, and inclosed in a cavity formed round them by its further deposit. Lacunæ formed from cartilage cells exist but very scantily. Examples occur in articular cartilage, and in that of the pubic symphysis, when, as commonly happens in mature life, the part of these tissues adjoining the bone is encroached on by a species of ossification, as noticed at page xcix. The ossifying process in this case is mere calcification of the cartilage, and stellate lacunæ, not

* Studier och Undersökningar öfver Benväfnaden. Stockholm. 1863.

intercommunicating by canaliculi, remain in the partially ossified cells. When this hard tissue is decalcified by an acid, the original cells and cartilaginous matrix become apparent.

Fig. LVI., A.

Fig. LVI., B.

Fig. LVI.—A and B represent Two Transverse Sections of Growing Bone, as in Fig. LIII., but much more magnified (about 120 diameters).

They show the lateral coalescence of the primary bony areolæ and the thickening of the sides of the enlarged cavities by new osseous deposit. The section A is made almost immediately below the surface of ossification; B, is somewhat lower, and shows the cavities still more enlarged and their sides more thickened than in A. The new osseous lining is transparent, and appears light in the figures; the dark ground within the areolæ is owing to opaque *débris*, which collected there in grinding the sections. It must be further noticed that the letter A within the larger figure marks a place where a bony partition had been accidentally broken away, for the large space was naturally divided into two.

As ossification advances towards the ends of the bone, the portion as yet cartilaginous continues to grow at the same time, and increases in every dimension. The part already osseous increases also in circumference; the medullary canal, of which for some time there is no appearance, begins to be excavated in the interior by absorption, and the sides of the shaft acquire

compactness and solidity. The increase in girth is brought about by deposition of bone at the surface underneath the periosteum. It has been sometimes supposed that a formation of cartilage precedes the bone also in this situation; but such is not the case, for the vascular soft tissue in immediate contact with the surface of the growing bone is not cartilage, but a blastema containing fibres and granular corpuscles; in fact, the increase takes place by intramembranous ossification, and accordingly the Haversian canals of the shaft are formed in the same way as those of the tabular bones of the skull,—that is, the osseous matter is not only laid on in strata parallel to the surface of the bone, but is deposited around processes of the vascular membranous tissue which extend from the surface obliquely into the substance of the shaft, (fig. LVII., *a*, *a*, in transverse section); and the canals in which these vascular processes lie, becoming narrowed by the deposition of concentric osseous laminæ, eventually remain as the Haversian canals (*c*, *c*).

Fig. LVII.

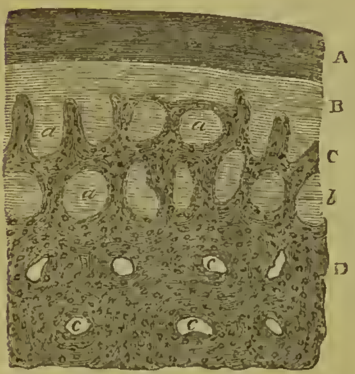


Fig. LVII.—Transverse Section of Superficial Part of Growing Metatarsal Bone of a Calf, magnified 45 diameters (from Kölliker).

A, periosteum; B, vascular soft tissue (sub-periosteal blastema of some writers); C, new bony growth with wide spaces, *a*, *a*, *a*, some being open grooves, others tubular, seen in cross section; D, more advanced and now compact tissue of the shaft, with the tubular spaces now nearly filled with concentric lamellæ leaving Haversian canals, *c*, *c*, in the centre. With a higher magnifying power, in the tissue B would be found fibres and granular cells, and layers of these cells everywhere covering the osteogenic deposit on the surface of the growing bone, and lining the grooves and tubular spaces.

That the ossification at the periosteal surface of the bone does not take place in cartilage, may be made apparent in the following manner. Strip off the periosteum from a growing bone at the end of the shaft, and from the adjoining cartilage also, taking care not to pull the latter away from the bone. A thin membranous layer will still remain, passing from the bone over the cartilage; now, take a thin slice from the surface, including this membrane with a very thin portion of the subjacent bone and cartilage, and examine it with the microscope, scraping off the cartilage from the inside if it be too thick. It will then be seen that the superficial part or shell of the bone, if it may be so called, is prolonged a little way over the surface of the cartilage by means of pellucid, coarsely reticulated fibres of soft tissue (fig. LVIII. *b*, *c*) into which the earthy deposit is advancing. These osteogenic fibres are intermixed with granular corpuscles or cells, but form no part of the cartilage, and they are no doubt of the same nature as those seen in the intramembranous ossification of the skull. Their reticulations are in most cases directed transversely, and sometimes they are little, if at all, in advance of the limit between the bone and cartilage. I have observed the structure here described in several bones of the (well advanced) fœtal sheep, also in the human scapula, humerus, femur, tibia and fibula, metacarpus and metatarsus, and, as was to be anticipated, it has since been found in all the long bones.

Ossification having thus proceeded for some time in the shaft, at length begins in the extremities of the bone from one or more independent centres, and extends through the cartilage, leaving, however, a thick superficial layer of it unossified, which permanently covers the articular end of the bone. The epiphyses thus formed continue long separated from the shaft or diaphysis by an intervening portion of cartilage, which is at last ossified, and the bone is then consolidated. The time of final junction of the

epiphyses is different in different bones; in many it does not arrive until the body has reached its full stature. Meanwhile the bone increases in length by the ossification continuing to extend into the intervening cartilage, which goes on growing at the same time; and it appears that in the part of the shaft already ossified little or no elongation takes place by interstitial growth. This is shown by an experiment first made by Dr. Hales and afterwards by Duhamel and by John Hunter, in which two or more holes being bored in the growing bone of a young animal at a certain measured distance from each other, they are found after a time not to be farther asunder, although the bone has in the mean while considerably increased in length.* In like manner the shaft also increases in circumference by deposition of new bone on its external surface, while at the same time its medullary canal is enlarged by absorption from within. A ring of silver or platinum put round the wing-bone of a growing pigeon, becomes covered with new bone from without, and the original bone included within it gets thinner, or, according to Duhamel, who first made the experiment, is entirely removed, so that the ring comes to lie within the enlarged medullary canal.

Fig. LVIII.

Fig. LVIII. — Subperiosteal Layer from the Extremity of the Bony Shaft of the Ossifying Tibia, as described in the text.

The cartilage and more open bony tissue have been scraped off from the inside of the crust, except at *a*, where a dark shade indicates a few vertical osseous areolæ out of focus and indistinctly seen. The part *a*, *b*, of the crust is ossified, and of granular aspect; between *b* and *c* are the clear reticulated fibres into which the earthy deposit is advancing. Magnified 150 diameters.

Madder given to an animal along with its food, tinges the earth of bone, which, acting as a sort of mordant, unites with and fixes the colouring matter. Now, that part of the bone which is most recently formed, and especially that part which is actually deposited during the administration of the madder, is tinged both more speedily and more deeply than the older part; and, as in this way the new osseous growth can be readily distinguished from the old, advantage was taken of the fact by Duhamel, and afterwards by Hunter, in their inquiries as to the manner in which bones increase in size. By their experiments it was shown that when madder is given to a young pig for some weeks, the external part of its bones is deeply reddened, proving that the new osseous matter is laid on at the surface of that previously formed. Again, it was found that when the madder was discontinued for some time before the animal was killed, an exterior white stratum (the last formed) appeared above the red one, whilst the internal white part, which was situated within the red,

* Hales Veget. Statics., 4th edit. p. 340; Duhamel Mem. de l'Acad. des Sc. 1743 et seq. Hunter (reported by Home) in Trans. of Soc. for Imp. of Med. and Chir. Knowledge, vol. ii.; also Catalogue of Hunterian Museum, vol. i. p. 249. Duhamel was led from some of his experiments to infer that an interstitial elongation took place near the ends; but there is some doubt left as to the precise circumstances of the experiments in these cases. Both Hales and Duhamel, in experimenting on the growing tibia of a chicken, observed that the addition of new bone was much greater at the upper end. Dr. Humphry has found that in the femur the elongation is greater at the *lower*, and in the humerus at the *upper* end of the shaft (Med. Chir. Trans. vol. xliv.).

and had been formed before any madder was given, had become much thinner; showing that absorption takes place from within. In this last modification of the experiment also, as noted by Mr. Hunter, a transverse red mark is observed near the ends of the bone, beyond which they are white; the red part, indicating the growth in length during the use of the madder, and the white beyond, that which has taken place subsequently,—thus showing that the increase in length is caused by the addition of new matter to the extremities.* But other changes take place in the bone. The spaces in the cancellated structure become enlarged, as well as the medullary canal, by absorption; whilst in other parts the tissue becomes more compact by farther deposit on the inner surface of the vascular cavities. The sides of the shaft in particular acquire greater solidity by the narrowing of the Haversian canals, within which the vascular membrane continues to deposit fresh layers of bone; and madder administered while this process is going on, colours the interior and recently-formed laminæ, so that in a cross section the Haversian apertures appear surrounded with a red ring. Lastly, Tomes and De Morgan have shown that in bones which have acquired their full size, a production of new systems of Haversian lamellæ continues throughout life, as described at page xciii.

From the foregoing account it is evident that a great portion of a long bone is formed independently of cartilage. Those physiologists, therefore, appear to have reason on their side, who consider the pre-existence of that tissue as not being a necessary condition of the ossific process, and who regard the precursory cartilage of the fœtal skeleton in the light of a temporary substitute for bone, and also as affording as it were a mould of definite figure and of soft but yet sufficiently consistent material in which the osseous tissue may be at first deposited and assume a suitable form. In fact the cartilage-cells are not ossified, and, as to the slender walls of the primary areolæ formed by calcification of the intercellular cartilaginous matrix, most of them are, in a long bone, swept away by absorption, in the excavation of the medullary canal; so that they can only remain—coated, however, and obscured by secondary laminated deposit—in the cancellar structure of bones which begin to ossify in cartilage.†

The time of commencement of ossification in the different bones, as well as the number and mode of conjunction of their bony nuclei, are subjects that belong to special anatomy. It may, however, be here remarked in general, that the commencement of ossification does not in all cases follow the order in which the bones appear in their soft or cartilaginous state. The vertebræ, for instance, appear as cartilages before there is any trace of the clavicle, yet ossification begins in the latter sooner than in any other bone of the skeleton. The time when it commences in the clavicle, and consequently the date of the first ossification in the skeleton, is referred by some to the seventh week of intra-uterine life; others assign a considerably earlier period; but owing to the uncertainty that prevails as to the age of early embryos, the dates of commencing ossification in the earliest bones cannot be given with precision.

In regard to the number and arrangement of the nuclei, the following general facts may be stated :—1. In the long bones there is one centre of ossification in the middle, and the ends are for the most part ossified from separate nuclei; whilst a layer of cartilage remains interposed until the bone has nearly attained its full length. By this means the bone is indurated in the parts where strength is most required, whilst its longitudinal growth is facilitated. 2. The larger foramina and cavities of the

* M. Flourens has repeated and varied these experiments, and represented the results in beautiful delineations. Recherches sur le Développement des Os et des Dents. Paris, 1842.

† Nesbitt, in 1736, maintained that the cartilage is "entirely destroyed;" he therefore considered it to be a mere temporary substitute; but the steps of the process of infracartilaginous ossification as now traced with the aid of the microscope were unknown to him. The view stated in the text, together with most of the facts adduced in support of it, was published in the fifth edition of this work in 1846, but, notwithstanding the comprehensive researches of Bruch, by which he was led to the same opinion (Denks. d. Schweitz. naturf. Gesells. 1852), it met with little notice, and probably less assent, until the subject was treated of in a special memoir by the late H. Müller (Zeits. für wissensch. Zool., vol. ix., 1858), to whom the doctrine in its modern shape is now commonly ascribed.

skeleton are for the most part formed by the junction of two, but more generally of three or more nuclei round the aperture or included space. The vertebral rings, the acetabulum, the occipital foramen, and the cranium itself, are illustrations of this. It is easy to conceive that in this way the ready and equable enlargement of such cavities and apertures is provided for. 3. Bones of a complex figure, like the vertebræ, have usually many nuclei; but the converse is not always true. 4. We can frequently connect the number of nuclei with the principle of uniformity of type on which the skeleton of vertebrated animals is constructed. Thus the typical form of the sternum seems to be that of a series of distinct bones, one placed between each pair of ribs in front, as the vertebræ are behind, and this is its permanent condition in many quadrupeds. In man it conforms to the archetype in its mode of formation, in so far as it is ossified from several centres, and for some time consists of several pieces; but, to suit the fabric of the human thorax, these at last coalesce one with another, and are reduced in number to three.

In the reunion of fractured bones, osseous matter is formed between and around the broken ends, connecting them firmly together; and when a portion of bone dies, as happens in necrosis, a growth of new bone very generally takes place to a greater or less extent, and the dead part is thrown off. The several steps of the process of restoration in these instances are so fully described in works on Surgical Pathology, that it is unnecessary to add to the length of this chapter by introducing an account of them here.

MUSCULAR TISSUE.

The muscular tissue is that by means of which the active movements of the body are produced. It consists of fine fibres, which are for the most part collected into distinct organs called muscles, and in this form it is familiarly known as the flesh of animals. These fibres are also disposed round the sides of cavities and between the coats of hollow viscera, forming strata of greater or less thickness. The muscular fibres are endowed with *contractility*, a remarkable and characteristic property, by virtue of which they shrink or contract more or less rapidly under the influence of certain causes which are capable of exciting or calling into play the property in question, and which are therefore named *stimuli*. A large class of muscles, comprehending those of locomotion, respiration, expression, and some others, are excited by the stimulus of the will, or volition, acting on them through the nerves; these are therefore named "voluntary muscles," although some of them habitually, and all occasionally, act also in obedience to other stimuli. There are other muscles or muscular fibres which are entirely withdrawn from the control of the will, such as those of the heart and intestinal canal, and these are accordingly named "involuntary." These two classes of muscles differ not only in the mode in which they are excited to act, but also to a certain extent in their anatomical characters; and on this account we shall consider the structure of each class separately.

Of the structure of voluntary muscles.—The voluntary muscular fibres are for the most part gathered into distinct masses or muscles of various sizes and shapes, but most generally of an oblong form, and furnished with tendons at either extremity, by which they are fixed to the bones.

The two attached extremities of a muscle are named, in anatomical descriptions, its origin and insertion,—the former term being usually applied to the attachment which is considered to be most fixed, although the rule cannot be always applied strictly. The fleshy part is named the belly, which in some cases is interrupted in the middle or divided into two by a tendon, and then the muscle is said to be biventral or digastric; on

the other hand it may be cleft at one end into two or three portions, in which case it is named bicipital or tricipital.

Fig. LIX.

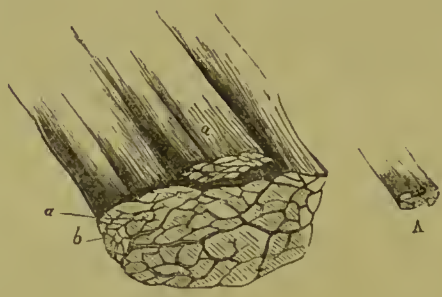


Fig. LX.

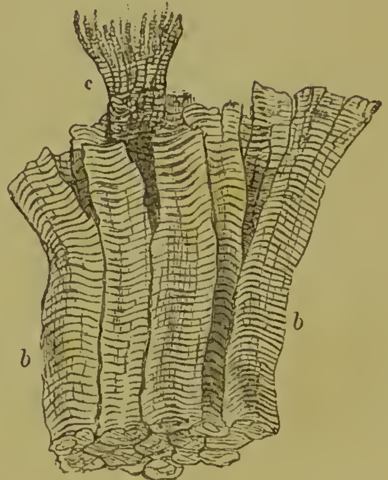


Fig. LIX.—A, Small Portion of Muscle, natural size; B, the same magnified 5 diameters, consisting of larger and smaller Fasciculi, seen in a Transverse Section.

Fig. LX.—A few Muscular Fibres, being part of a small Fasciculus, highly magnified, showing the Transverse Striæ.

a, end view of *b*, *b*, fibres; *c*, a fibre split into its fibrils.

The muscular fibres are collected into packets or bundles, of greater or less thickness, named fasciculi or lacerti (fig. LIX.), and the fibres themselves consist of much finer threads, visible by the aid of the microscope, which are termed muscular filaments, fibrillæ or fibrils (fig. LX., *c*). The fibrils run parallel with each other in the fibres, and the fibres are parallel in the fasciculi and the fasciculi extend continuously from one terminal tendon to the other, unless in those instances, like the rectus muscle of the abdomen and the digastric of the inferior maxilla, in which the fleshy part is interrupted by interposed tendinous tissue. The fasciculi also very generally run parallel, and although in many instances they converge towards their tendinous attachment with various degrees of inclination, yet in the voluntary muscles they do not interlace with one another.

Sheath.—An outward investment or sheath of areolar tissue (sometimes named *perimysium*) surrounds the entire muscle, and sends partitions inwards between the fasciculi; furnishing to each of them a special sheath. The areolar tissue extends also between the fibres, but does not afford to each a continuous investment, and therefore cannot be said to form sheaths for them. Every fibre, it is true, has a tubular sheath; but this, as will be afterwards explained, is not derived from the areolar tissue. The tissue of the sheath is composed of elastic (yellow) as well as of white fibres; but the elastic element is found principally in its investing (as distinguished from its penetrating) portion. The chief uses of the areolar tissue are to connect the fibres and fasciculi together, and to conduct and support the bloodvessels and nerves in their ramifications between these parts. The relation of these different subdivisions of a muscle to each other, as well as the shape of the fasciculi and fibres, is well shown by a transverse section (figs. LIX. and LX.).

Section IV.—ANGEIOLOGY.

Under the name of Angeiology is included the descriptive anatomy of the vascular system, consisting of the heart, blood-vessels and absorbents. The *heart* is the central organ of the circulation, and although presenting a complex structure and mechanism, may be regarded, when viewed with reference to its development, as a curved and greatly altered blood-vessel. The *blood-vessels* are of three kinds—viz., the *arteries*, or ramifying vessels which distribute the blood from the heart; the *capillaries*, or network of simple walled microscopic vessels, in which the blood is diffused through the tissues; and the *veins*, or vessels by which the blood is returned to the heart. The *absorbents* are the small and delicate vessels which convey into the circulation fluid material capable of being converted into blood, whether derived directly from the food digested in the alimentary canal, or returned from the tissues in which it has already played some part in the nutritive processes.

The double circulation.—In the *systemic circulation* the blood is conveyed from the left ventricle of the heart by the arteries to every part of the body, and having parted in the capillaries with a portion of its ingredients, and undergone changes which render its purification necessary, it is returned by the veins to the right side of the heart, which is distinct from that from which it set out. The dark-coloured blood thus brought back to the right side of the heart is conducted through the *pulmonary circulation*, being propelled through the pulmonary artery by the right ventricle, undergoing in the lungs a process of purification, in which it receives oxygen from the air and parts with carbonic acid, and returning thence to the heart by the pulmonary veins, again to enter the systemic circulation.

THE HEART.

RELATION TO SURROUNDING PARTS.

The heart is situated in the thorax, between the two lungs, and, together with the adjacent parts of the great vessels which convey blood to and from it, is enclosed by a membranous covering, the pericardium. It is placed behind the sternum and the costal cartilages, occupying a region of about four inches in width, extending from the second intercostal space on the right side to the fifth space on the left, and reaching considerably farther on the left than on the right of the middle line.

THE MEDIASTINUM.

The greater part of the thorax is occupied by the lungs, each of which is invested with a serous membrane, the pleura, which presents a parietal and a visceral portion, and is continued from the one portion to the other by passing on the surface of the pericardium from the anterior and posterior parts of the walls of the chest to the root of the lung. Thus the heart, enclosed in the pericardium, is situated between the right and left pleural sacs, and between the layers of an antero-posterior septum formed by the united portions of the right and left pleuræ, and known as the mediastinum.

Fig. 221.

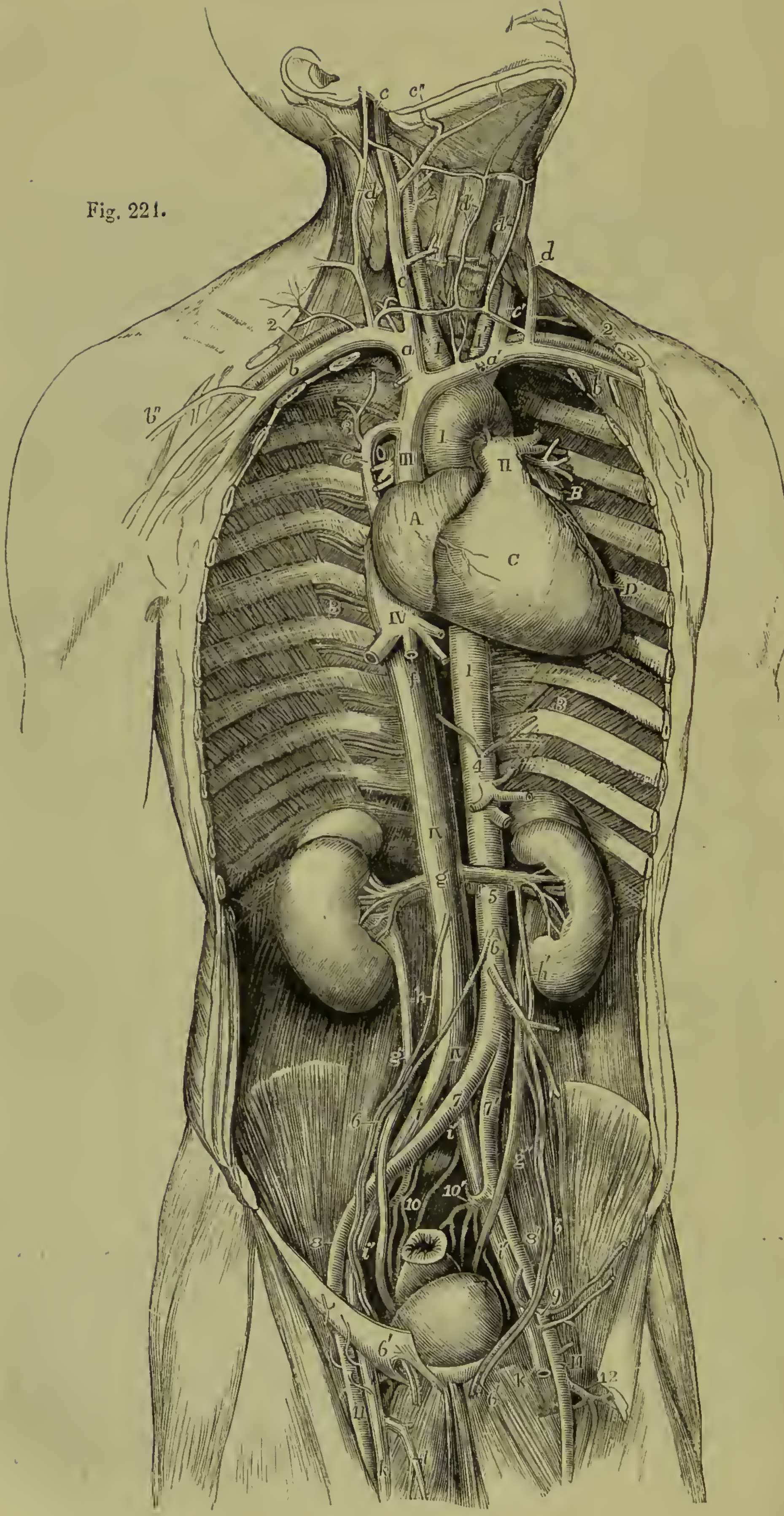


Fig. 224.—General View of the Principal Organs of Circulation, from before and from the right side in a Male Adult. $\frac{1}{4}$

A, Right auricle; B, left auricular appendix; C, right ventricle; D, small part of the left ventricle; I, placed on the first part of the aortic arch; and on the descending aorta; II, trunk of the pulmonary artery dividing into its right and left branches, and connected to the aorta by the cord of the ductus arteriosus; III, vena cava superior; IV, vena cava inferior.

1, innominate artery and right carotid; 1′, left carotid; 2, right and left subclavian arteries; 3, intercostal vessels marked only in three spaces; 4, above this figure the inferior diaphragmatic arteries, below it the cœliac axis and superior mesenteric artery; 5, renal arteries; 6, above this figure the spermatic arteries, and below it the inferior mesenteric; 6′, the farther course of the spermatic vessels, on the right side they are seen to pass through the outer abdominal ring before descending to the testis; 7, 7′, right and left common iliac arteries; 8, 8′, external iliac arteries; 9, epigastric and circumflex iliac arteries of the left side; 10, 10′, internal iliac arteries; and between these two figures the middle sacral artery; 11, femoral arteries; 12, some branches of the profunda femoris artery of the left side.

a, right innominate or brachio-cephalic vein; *a′*, the left; *b*, *b′*, right and left subclavian veins; *b″*, the cephalic vein of the right arm; *c*, *c′*, internal jugular veins; *c″*, right facial vein joining the internal jugular; *d*, external jugular veins formed by the posterior auricular and temporal veins; *d′*, anterior jugular veins with the transverse joining the external jugular; *e*, azygos vein passing over the root of the right lung; *f*, one of the hepatic veins; *g*, placed on the vena cava inferior at the origin of the renal veins; to the sides are seen the kidneys and the suprarenal bodies; *g′*, right, *g″*, left ureter; *h*, right spermatic vein; *h′*, the left, joining the left renal vein; *i*, *i*, common iliac veins; *i′*, *i′*, external iliac veins; *k*, femoral veins; *l*, saphenous vein of the right side.

The part of this septum behind the pericardium is distinguished as the *posterior mediastinum;* it is in front of the bodies of the vertebræ, and within its cavity are the trachea, the œsophagus, the thoracic duct, the descending aorta, the vena azygos, and the pneumogastric nerves, with lymphatic vessels and areolar tissue. The *middle mediastinum* is the name given to the larger space, which is occupied by the pericardium and its contents. The *anterior mediastinum*, in front of the pericardium, is narrow and of little depth; but a knowledge of its situation is important to the physician, as it is connected with the position of the anterior margins of the lungs relatively to the heart: at its superior part a small interval is left

Fig. 225.

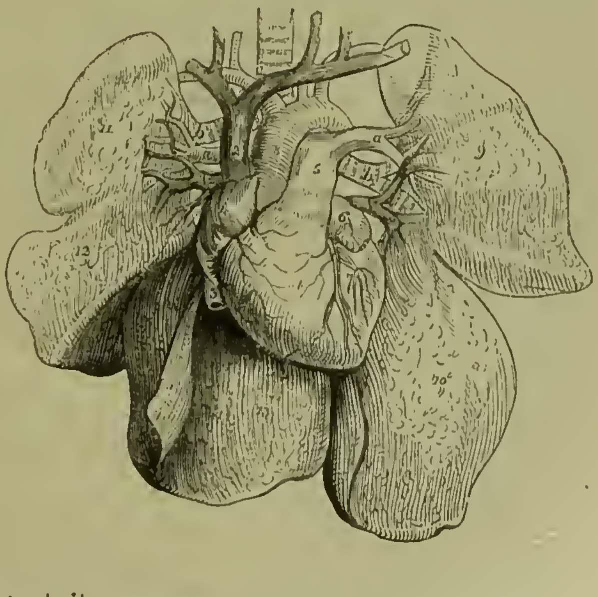


Fig. 225.—A Diagrammatic Representation of the Heart and Great Vessels in connection with the Lungs. $\frac{1}{6}$

The pericardium has been removed, and the lungs are turned aside. 1, right auricle; 2, vena cava superior; 3, vena cava inferior; 4, right ventricle; 5, stem of the pulmonary artery; *a*, *a*, its right and left branches; 6, left auricular appendage; 7, left ventricle; 8, aorta; 9, 10, two lobes of the left lung; 11, 12, 13, three lobes of the right lung; *b*, *b*, right and left bronchi; *v*, *v*, right and left upper pulmonary veins.

between the two layers of pleura which bound it, and in this are contained the vestiges of the thymus gland ; behind the second piece of the sternum the pleuræ of opposite sides come into contact, and the anterior mediastinum is reduced to a thin septum; while lower down it is inclined to the left, and widened out into an angular space of some breadth, by the margin of the left pleura receding from the sternum : opposite the lower part of this space the apex of the heart is situated, and in front of it is placed the triangularis sterni muscle.

THE PERICARDIUM.

This membranous bag, in which the heart is contained, is of a somewhat conical shape, its base being attached below to the upper surface of the diaphragm, whilst the apex, or narrower part, surrounds the great vessels which spring from the cavities of the heart, as far as their first subdivisions. It consists of two layers, one external and fibrous, the other internal and serous.

The *fibrous* layer is a dense, thick and unyielding membrane, consisting of fibres which interlace in every direction. At the base of the pericardium these fibres are firmly attached to those of the central aponeurosis of the diaphragm ; and above, where the pericardium embraces the large blood-vessels, the fibrous layer is continued on their surface in the form of tubular prolongations, which become gradually lost upon their external coats. The superior vena cava, the four pulmonary veins, the aorta, and the right and left divisions of the pulmonary artery, in all eight vessels, receive prolongations of this kind.

The *serous* layer not only lines the fibrous layer of the pericardium and the part of the diaphragm to which that layer is attached, but like other serous membranes, is reflected on the surface of the viscus which it invests. It has, therefore, a visceral and a parietal portion. The parietal portion adheres firmly by its outer surface to the fibrous membrane, and becomes continuous with the visceral portion upon the arch of the aorta and other great vessels, about two or two and a half inches from the base of the heart. In passing round the aorta and pulmonary artery, it encloses both those vessels in a single short tubular sheath. It is reflected also upon the superior vena cava and on the four pulmonary veins, and forms a deep recess or prolonged cavity between the entrance of the right and left veins into the left auricle. The inferior vena cava receives only a very scanty covering of this membrane, inasmuch as that vessel enters the right auricle almost immediately after passing through the diaphragm, and is only partially surrounded by a reflection of the pericardium in the narrow interval between these parts. None of the vessels, indeed, joining the heart, with the exception of the aorta and pulmonary artery where they are united together, receive a complete covering from the pericardium, or can be said to pass entirely through the sac: portions only of the membrane are inflected round them more or less fully.

On separating the left pulmonary artery and subjacent pulmonary vein, a fold of the pericardium will be seen between them, which has been termed by Marshall the "vestigial fold of the pericardium." It is formed by a duplicature of the serous membrane, including areolar and fatty tissue, together with some fibrous bands, blood-vessels, and nerves. It is from half to three-quarters of an inch in length, and from a half to one inch deep. Above the pulmonary artery it blends with the pericardium, and passes onwards to the left superior intercostal vein. Below, it is lost, on the side of the left auricle, in a narrow streak which crosses round the lower left

Fig. 226.

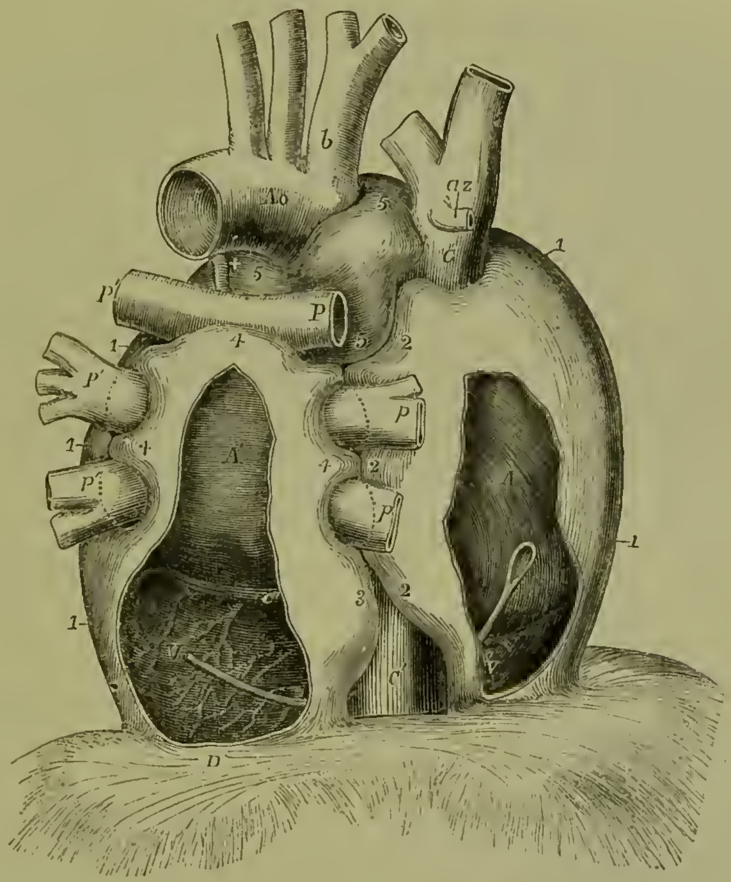


Fig. 226.—Semi-diagrammatic View of the Pericardium from behind, designed to show the principal inflections of the Serous Sac round the Great Vessels. $\frac{1}{2}$

The drawing is taken from a preparation in which the heart and vessels had been partially filled by injection, the pericardium inflated and dried in the distended state, and the fibrous continuation on the vessels removed. By the removal of a portion of the pericardium from behind the right and left cavities of the heart, the position of that organ is made apparent. A bent probe is passed within the pericardium from behind the right auricle in front of the vena cava inferior to the back of the left ventricle, which may indicate the place where the large undivided sac of the pericardium is folded round that vein. A, posterior surface of the right auricle; A′, the same of the left; V, right ventricle; V′, left ventricle; Ao, the upper and back part of the aortic arch; *b*, innominate artery; C, vena cava superior; *az*, azygos vein; C′, vena cava inferior between the diaphragm and its union with the right auricle; *c″*, great coronary vein; +, cord of the ductus arteriosus; P, the right, P′, the left pulmonary artery; *p*, the right, *p′*, the left pulmonary veins; D, the back of the central tendon of the diaphragm; 1, the great undivided sac of the pericardium proceeding from before backwards towards its inflections round the vessels; 2, portion of this on the right side which partially surrounds the vena cava superior, the upper and lower right pulmonary veins, and the vena cava inferior; 3, the portion of the left side which partially surrounds the vena cava inferior; 4, the portion which is extended upwards behind the left auricle, and partially folds over the pulmonary arteries and veins, and which meets between these different vessels the extensions of the main sac from the right and left; 5, tubular portion of the pericardium which completely surrounds the aortic and pulmonary arterial trunks.

pulmonary vein. This is shown, by Marshall, to be a vestige of the cardiac termination of the great left anterior vein existing in early embryonic life. (Marshall, "On the development of the great anterior Veins in Man and Mammalia," Philosoph. Trans. 1850. Part I. See hereafter the figures of the coronary vein.)

EXTERNAL FORM OF THE HEART.

The heart is a hollow muscular organ, divided by a longitudinal septum into a right and left half, each of which is again subdivided by a transverse constriction into two compartments, communicating with each other, and named *auricle* and *ventricle.* Its general form is that of a blunt cone, flattened on its under surface. The broader end or base, by which it is attached, is directed upwards, backwards, and to the right, and extends from the level of the fourth to that of the eighth dorsal vertebra. The apex is turned downwards, forwards, and to the left, and corresponds in the dead body with the cartilage of the sixth rib. In the living subject its stroke against the walls of the chest is felt in the space between the cartilages of the fifth and sixth ribs, a little below and within the left mammilla. The heart, therefore, has an oblique position in the chest, and besides this is nonsymmetrically placed, as it projects farther into the left than into the right half of the thoracic cavity, passing on an average about an inch or an inch and a half beyond the middle line in the one direction, and upwards of three inches in the other. Its position is affected more or less by that of the body; thus it comes more extensively into contact with the anterior walls of the

Fig. 227.

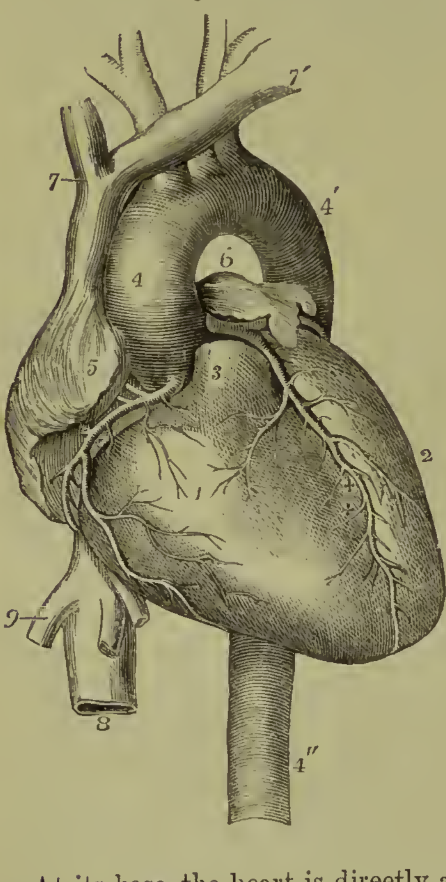


Fig. 227.—View of the Heart and Great Vessels from before (from R. Quain). ⅓

The pulmonary artery has been cut short close to its origin in order to show the first part of the aorta. 1, anterior part of the right ventricle; 2, left ventricle; 3, root of the pulmonary artery; 4, ascending part of the arch of the aorta; 4′, the posterior or descending part of the arch; between these is seen the transverse or middle part from which the brachio-cephalic arteries take their origin; 4″, the descending thoracic aorta; 5, the appendix and anterior part of the right auricle; 6, those of the left auricle; 7, the right, and 7′, left innominate or brachio-cephalic veins joining to form the vena cava superior; 8, the inferior vena cava below the diaphragm; 9, one of the large hepatic veins; +, placed in the right auriculo-ventricular groove, points to the right or posterior coronary artery; + +, placed in the anterior inter-ventricular groove, points to the left or anterior coronary artery.

chest when the body is in the prone posture or lying on the left side. In inspiration, on the other hand, when the diaphragm sinks and the lungs expand, its apex is withdrawn from the thoracic parietes.

At its base the heart is directly attached to the great blood-vessels, and it is also connected with them by the serous layer of the pericardium, which passes from the one to the other. In the remainder of its extent the heart is entirely free, and movable within the sac of the pericardium. The

anterior surface is convex in its general form ; it is turned upwards as well as forwards, and is directed towards the sternum and costal cartilages : from these, however, it is partly separated by the lungs, the forepart of these organs advancing over it to some extent, and encroaching still farther during inspiration, so as in that condition to leave usually not more than two inches square uncovered. The posterior, which is also the under surface, is flattened, and rests on the diaphragm. Of the two borders or margins formed by the meeting of the anterior and posterior surfaces, the right or lower border, called *margo acutus,* is comparatively thin, and is longer than the upper or left border, which is more rounded and is named *margo obtusus.*

A deep transverse groove, the *auriculo-ventricular furrow,* interrupted in front by the root of the pulmonary artery, divides the heart into the auricular and the ventricular portions ; and on the ventricular portion two *longitudinal furrows* indicate the position of the anterior and posterior borders of the septum which divides one chamber from the other.

Fig. 228.

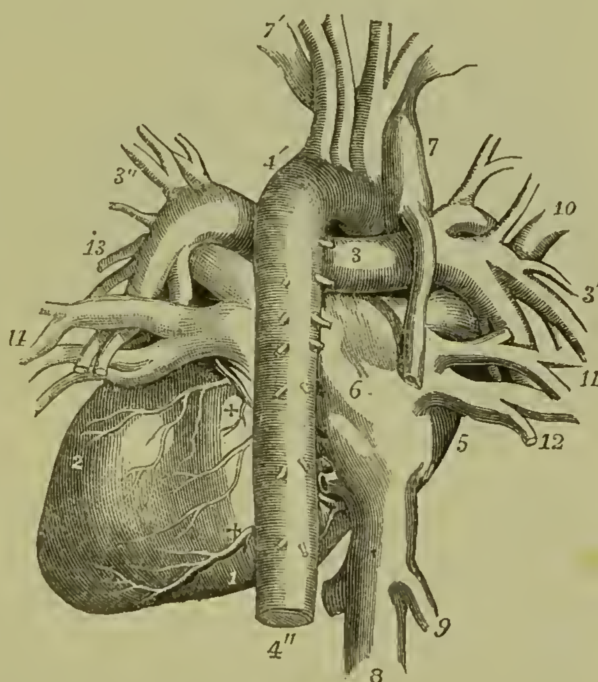


Fig. 228. — View of the Heart and Great Vessels from behind (from R. Quain).

1, posterior surface of the right ventricle ; 2, the same of the left ; 3, placed on the back of the right pulmonary artery near the division of the primary trunk ; 3′, branches of the right pulmonary artery passing into the root of the right lung ; 3″, the same of the left ; 4′, back part of the arch of the aorta ; 4″, descending thoracic aorta ; 5, part of the right auricle ; 6, is placed on the division between the right and left auricles ; 7, superior vena cava ; 7′, left vena innominata ; 8, trunk of the inferior vena cava ; 9, right large hepatic vein ; 10, 11, 12, right pulmonary veins ; 13, 14, left pulmonary veins ; +, +, posterior branches of the right and left coronary arteries.

The auricular portion, situated above and behind the transverse furrow, is thin and flaccid, and is immediately connected with the great veins ; it is divided by an internal septum into two distinct cavities, which have received the names of the right and left *auricles*, from the circumstance that each is provided with an appendage somewhat resembling the ear of a dog. The ventricular portion, placed below and in front of the transverse groove, is somewhat conical, flattened on its posterior or under surface, has very thick walls, and is connected with the great arterial trunks. The two longitudinal furrows, which mark its division into a right and left chamber, situated one on the anterior, the other on the posterior surface, extend from the base of the ventricular portion, in a direct course, and are continuous one with the other a little to the right of the apex, which is thus formed entirely by the wall of the left ventricle. The anterior longitudinal furrow is nearer to

the left border, whilst the posterior furrow approaches nearer to the right border of the heart, the right ventricle forming more of the anterior, and the left more of the posterior surface of the organ. Within the transverse and longitudinal furrows are placed the proper nutrient vessels of the heart, the coronary or cardiac arteries and veins, with the lymphatic vessels and nerves imbedded in fatty and connective tissue.

INTERIOR OF THE HEART.

General description.—Considered in respect of function, the heart is a double organ, composed of a right and a left part, each consisting of an auricle and a ventricle. The right portion receives into its auricle from the two venæ cavæ and coronary veins the dark venous blood returning from the various parts of the body and from the heart itself, and, by means of its ventricle, propels that blood through the pulmonary artery into the lungs. The red blood returning from the lungs by the pulmonary veins, reaches the left auricle of the heart, and is forced onwards by the left ventricle, through the aorta and its branches into every part of the body. The right and left divisions of the heart present in various respects a similar anatomical structure, and the features which are common to both may here be shortly referred to before passing to those which are peculiar to one auricle or ventricle.

Endocardium.—The interior of the whole heart is invested with a lining membrane, similar in general appearance to the visceral layer of pericardium which covers the exterior, but belonging to the class of vascular lining membranes, and continuous with that of the blood-vessels. This internal lining, or *endocardium*, is a thin transparent membrane, differing slightly on the two sides of the heart. On the left side of the heart it is continuous with the lining membrane of the pulmonary veins and aorta, and is usually found more opaque than on the right side, whence it is prolonged into the veins of the body and into the pulmonary artery.

According to Theile, the endocardium is very thin on the musculi pectinati of the auricles and on the columnæ carneæ of the ventricles. It is thicker, however, on the smooth walls of the auricular and ventricular cavities, and on the musculi papillares, especially near their tips. It is, on the whole, thicker in the auricles than in the ventricles, and attains its greatest strength in the left auricle. In both auricles the endocardium consists of three layers. On the free surface is an epithelial stratum of polygonal cells. Beneath the epithelium is a network of elastic fibres, often containing portions of fenestrated membrane; and connecting the latter to the muscular substance of the heart, is a layer of areolar tissue. Purkinje and Raeuschel (De Arteriarum et Venarum Structura. Breslau, 1836.) found elastic fibres beneath the endocardium in both auricles, and in the corpora Arantii, but not in the ventricles.

The *auricles* are both of them divisible into a large cavity, called the *atrium*, or sinus venosus, and a much smaller part in front, the *auricular appendage*, *auricula*, or *auricle proper*. The interior of the atrium presents smooth walls in the greater part of its extent, but the walls of the auricular appendages are thrown into closely-set reticulated bands, which in the right extend also into the sinus, and are named *musculi pectinati*. The auricle, both on the right and the left side, receives the blood from the veins, and transmits it into the corresponding ventricle by the auriculo-ventricular opening.

The *ventricles*, on a great part of their inner surfaces, are covered with a number of irregular rounded muscular bands, named *columnæ carneæ*, which form quite a network in some parts of the ventricle, and may be classified into three kinds. The *first* kind form merely slightly prominent ridges on the walls of the ventricle, being attached by one of their sides as well as by the two extremities ; the *second* are adherent by their two ends only, and are free in the rest of their extent ; whilst the third kind form a few bundles, named *musculi papillares*, which are directed in general from the apex towards the base of the ventricle, in which they are attached to the muscular wall by their broader bases, and tapering more or less at their free extremities give rise to small tendinous cords, *chordæ tendineæ*, through which they are connected with the segments of the auriculo-ventricular valve. Each ventricle has two orifices, an auriculo-ventricular and an arterial opening.

Fig. 229.

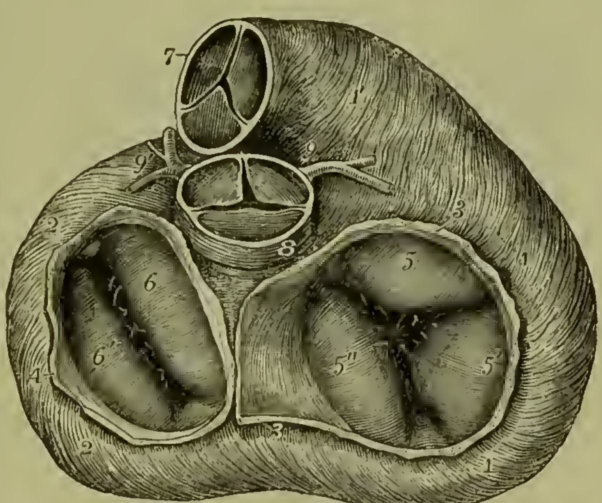


Fig. 229.—View of the Base of the Ventricular Part of the Heart, showing the relative position of the Arterial and Auriculo-ventricular orifices. $\frac{2}{3}$

The muscular fibres of the ventricles are exposed by the removal of the pericardium, fat, bloodvessels, &c.; the pulmonary artery and aorta have been removed by a section made immediately beyond the attachment of the semi-lunar valves, and the auricles have been removed immediately above the auriculo-ventricular orifices. The semilunar and auriculo-ventricular valves are in the closed condition. 1, 1, the base of the right ventricle ; 1′, the conus arteriosus ; 2, 2, the base of the left ventricle ; 3, 3, the divided wall of the right auricle ; 4, that of the left ; 5, the anterior, 5′, the posterior, and 5″, the left or septal segment of the tricuspid valve ; 6, the anterior or aortic, and 6′ the left and posterior segment of the mitral valve. In the angles between these segments are seen the smaller fringes frequently observed ; 7, the anterior part of the pulmonary artery ; 8, placed upon the posterior part of the root of the aorta ; 9, the right, 9′, the left coronary artery.

Valves.—In order to give to the blood propelled by the contraction of the ventricles its due direction through the arteries, two sets of valves are provided, one of which prevents the regurgitation of blood through the auriculo-ventricular openings into the auricles during the contraction of the ventricles, while the other prevents regurgitation from the arteries back into the ventricles when the contraction has ceased. These valves are mainly formed of folds of the endocardium with some fibrous tissue contained within them.

The *auriculo-ventricular* valves are composed of membranous flaps or segments, which are three in number in the valve of the right side, and two in that of the left. At their bases, the several segments are continuous with one another, so as to form an annular membrane attached round the margin of the auricular opening : they are directed downwards,

and are retained in position within the ventricle by the chordæ tendineæ, which are attached to their ventricular surfaces and free margins.

Fig. 230.

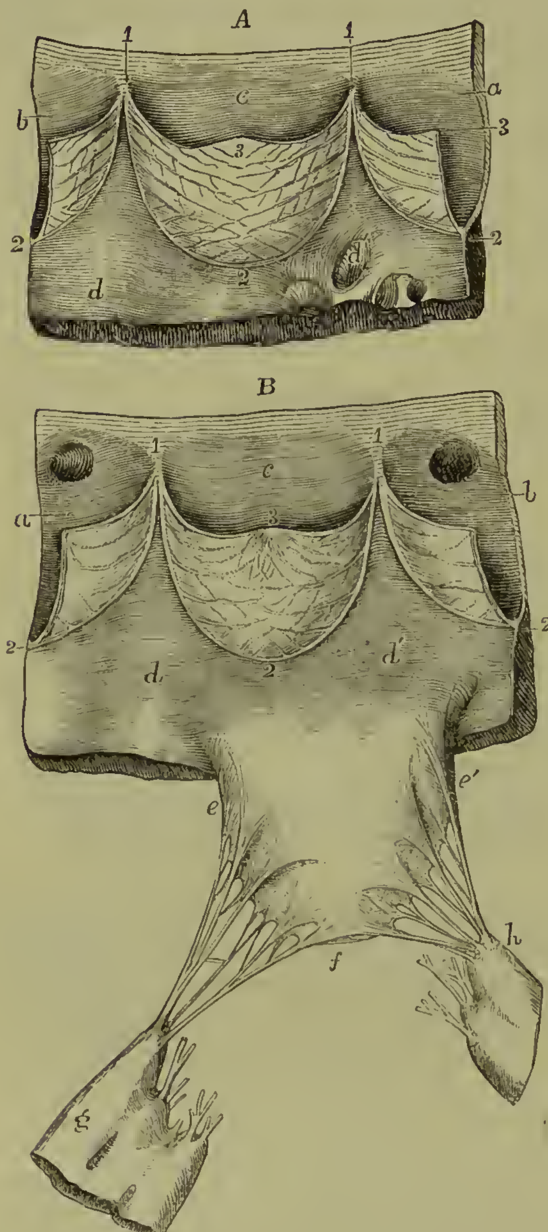


Fig. 230.—Views of parts of the Semilunar and Mitral Valves, as seen from within the Ventricle.

A, portion of the pulmonary artery and wall of the right ventricle with one entire segment and two half segments of the semilunar valves; *a*, half the sinus of Valsalva of the anterior segment; *b*, the same of the left posterior segment; *c*, the entire right posterior segment (see Fig. 231, A, in which the lettering is the same as in the present figure); *d*, *d'*, inner surface of the ventricle; 1, the attachment of the extremities of the segments to the inner wall of the artery; 2, the middle of the attached border of the segments; 3, the middle of the free border marked in two of the segments; upon the middle segment especially the direction of the bands of fibres strengthening the valve, as represented by Pettigrew, is shown.

B, portion of the aorta and wall of the left ventricle with one entire segment and two half segments of the semilunar valve, and the right or anterior segment of the mitral valve; *a*, half the right anterior sinus of Valsalva and segment (marked *b* in B, fig. 231); *b*, the same of the left side; *c*, the posterior sinus of Valsalva and segment entire; in *a*, and *b*, the apertures of the coronary arteries are seen; *d*, *d'*, the inner surface of the wall of the ventricle to the right of the auriculo-ventricular orifice; 1, 1, the attachments of the extremities of the segments; 2, the middle of the attached borders; 3, the middle of the free border with the corpus Arantii shown in the middle segment; *c*, *c'*, the base of the right or anterior segment of the mitral valve; *f*, its apex; between *c*, and *c'*, and *f*, the attachment of the branched chordæ tendineæ to the margin and outer surface of the valve segment; *g*, the posterior principal musculus papillaris; *h*, the anterior principal musculus papillaris: the cut chordæ tendineæ are those which belong to the left or posterior segment and the small or intermediate segments.

During the contraction of the ventricles, the segments of the valves are applied to the openings leading from the auricles, and prevent the blood from rushing back into those cavities. Being retained by the chordæ tendineæ, the expanded flaps of the valve resist the pressure of the blood, which

would otherwise force them back through the auricular orifice; the papillary muscles, shortening as the cavity of the ventricle itself is contracted during its systole, are supposed thus to prevent the valves from yielding too much towards the auricle, which might have been the case had the chordæ tendineæ been longer, or fixed directly into the wall of the ventricle. The middle part of each segment is thicker than the rest, whilst the marginal part is thinner, more transparent, and jagged at the edges. In the angles between each pair of the principal segments of the auriculo-ventricular valves there may be found, but not constantly, as many small intermediate lobes. The musculi papillares are arranged in groups as many as there are segments of the valve, and the chordæ tendineæ from each are distributed to the adjacent sides of two different valves, so as to draw their margins together.

According to Kürschner (Wagner's Handwörterbuch, art. "Herzthätigkeit"), three kinds of cords belong to each segment: *a*, the first set, generally two to four in number and proceeding from two different sets of papillæ, or from one of these and the wall of the ventricle, run to the base or attached margin of the segment, and are there connected also with the tendinous ring round the auriculo-ventricular opening; *b*, the second set, more numerous, and smaller than the first, proceed also from two adjacent papillary muscular groups, and are attached to the back or ventricular surface of each segment at intervals along two or more lines extending from the points of attachment of the tendons of the first order at the base of the valve to near its free extremity; *c*, the third set, which are still more numerous and much finer, branch off from the preceding ones, and are attached to the back and edges of the thinner marginal portions of the valves. A few muscular fibres prolonged from the neighbouring walls penetrate into the segments of the auriculo-ventricular valves.

Fig. 231.

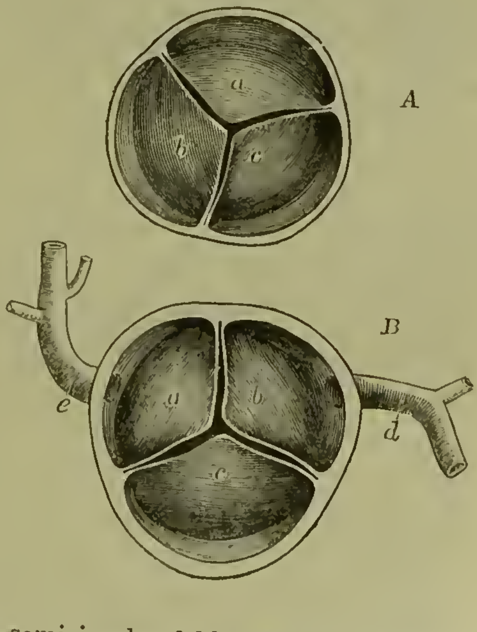


Fig. 231.—The Semilunar Valves of the Aorta and Pulmonary Artery, seen from their Distal Side.

A, transverse section of the pulmonary artery immediately above the attachment of the semilunar valves: *a*, the anterior segment; *b*, the left, and *c*, the right posterior segments: in each the sinus of Valsalva is seen, and between them the attachment of the ends of the valve-segments to the inner wall of the artery.

B, a similar section of the aorta, showing the semilunar valves from their distal side: *a*, the left, *b*, the right anterior segments, with the sinuses of Valsalva, from which the corresponding coronary arteries are seen to take their origin; *c*, the posterior segment; *d*, the right, or posterior; *e*, the left, or anterior coronary arteries.

The *semilunar* or *sigmoid* valves, placed at the mouths of the aorta and pulmonary artery, consist of three semicircular folds, each of which is attached by its convex border to the side of the artery at the place where it joins with the ventricle, whilst its other border, nearly straight, is free, and projects into the interior of the vessel. They are composed of dupli-

catures of the endocardium, and of enclosed fibrous structure, which varies in thickness at different parts. A tendinous band strengthens the free margin of the valve, and is attached at the middle of that margin to a slight fibro-cartilaginous thickening, the *nodulus* or corpus *Arantii.* Other tendinous fibres, spreading out from the attached border of the valve, run into the valve and towards the nodule, occupying its whole extent, except two narrow lunated portions, one on each side, adjoining the free margin of the valve. These parts, which are named *lunulæ*, are therefore thinner than the rest. There is also a strengthening fibrous cord surrounding the attached border of each valve. (For further information regarding the structure of the valves, consult Pettigrew, in Trans. Roy. Soc. Edin. 1864.)

During the contraction of the ventricle the valves lie against the sides of the artery, and allow the blood to flow freely past them ; but during the ventricular diastole, when the column of fluid in the artery is partially thrown back by the elasticity of the coats of that vessel, the sigmoid valves are distended by the regurgitating blood, and completely close the arterial orifice. When the valves are thus closed, the whole free border and the thin lunated parts are closely applied to each other, and are held together as well as exempted from strain by the opposite and equal pressure of the blood on either side, so that the greater the pressure the more accurate must be the closure. The force of the reflux is sustained by the stouter and more tendinous part of the valve. (Retzius, in Müller's Archiv., 1843, p. 14.)

Opposite the pouches formed by the sigmoid valves, the commencing aorta and pulmonary artery present dilatations or recesses in their walls, called *sinuses of Valsalva*, which give to the transverse section of the vessel a trilobate form, and as one of these is placed behind each segment of the valve, it thus forms along with it a cup-shaped cavity.

Special description.—The detailed anatomy of the four cavities of the heart may be conveniently considered in the order of the course of the blood in its double circulation through them from the venæ cavæ to the aorta.

1. The right auricle forms the right anterior and lower part of the base of the heart, and is in contact below with the pericardium where it lies upon the diaphragm : it receives blood in two large streams, from the superior and the inferior vena cava, besides the smaller quantity from the coronary vein. At its fore part its auricular appendage projects forwards and to the left, in front of the aorta, as far as the pulmonary artery. This part is triangular in form, compressed and slightly dentated at its border, and has more strongly muscular walls than the sinus venosus. The auricular appendage and anterior wall of the sinus venosus are closely ridged in a vertical direction with musculi pectinati ; the remaining parts of the walls are comparatively smooth. The superior vena cava is directed downwards and forwards into the upper part of the auricle, while the inferior vena cava terminates in the lower and back part by a considerably larger opening, which is directed upwards and inwards. In the floor of the auricle, in front of the inferior vena cava, is the auriculo-ventricular opening, leading into the right ventricle ; it is oval in form, and about an inch and a quarter in diameter, admitting three fingers easily. The other foramina opening into the right auricle are, the orifice of the large coronary vein of the heart, situated between the opening of the inferior vena cava and the auriculo-ventricular opening, and a number of small pits,

foramina Thebesii, some of which are recesses closed at the bottom, whilst others are the mouths of minute veins (venæ minimæ cordis).

The left and posterior side of the auricle is formed by the *septum auricu-*

Fig. 232.

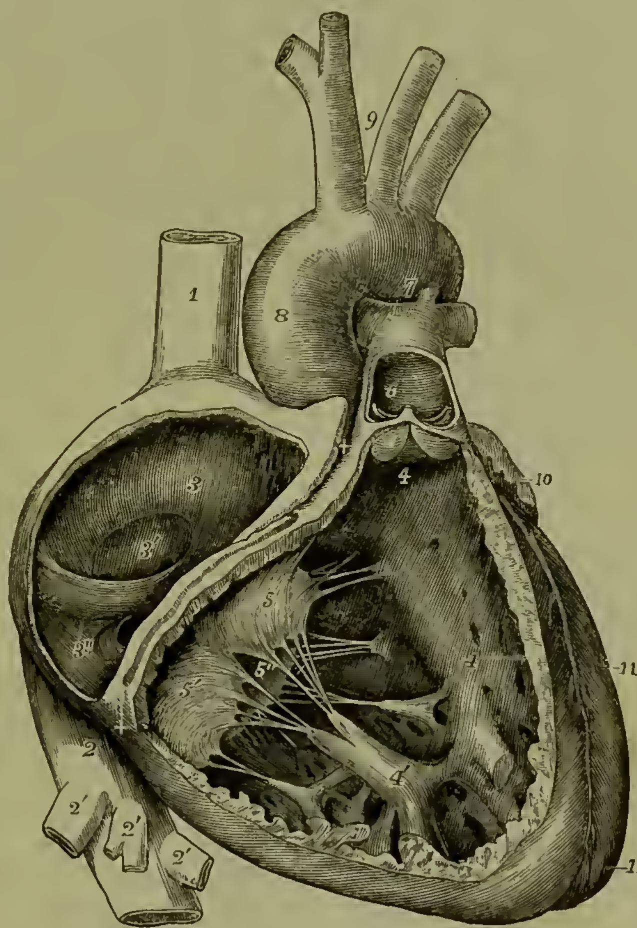


Fig. 232.—The Right Auricle and Ventricle opened and a part of their Right and Anterior Walls removed so as to show their interior. ½

1, the superior vena cava; 2, the inferior vena cava at the place where it passes through the diaphragm, and below the hepatic veins; 2′, the hepatic veins cut short; 3, placed upon the tubercle of Lower within the cavity of the right auricle; 3′, placed in the fossa ovalis, below which is the Eustachian valve; 3″, is placed close to the aperture of the great coronary vein and the valve of Thebesius; +, +, placed in the auriculo-ventricular groove, where a narrow portion of the adjacent walls of the auricle and ventricle has been preserved; 4, 4, the cavity of the right ventricle on the right side of the septum, the upper figure is immediately below the semilunar valves; 4′, large right columna carnea; 5, the anterior, 5′, the posterior, and 5″, the left or septal segment of the tricuspid valve; 6, placed in the interior of the pulmonary artery, a part of the anterior wall of that vessel having been removed, and a narrow portion of it preserved at its commencement where the semilunar valves are attached. The valves are represented as in a half-closed position; two of the segments are seen fore-shortened, the third sideways; 7, concavity of the aortic arch close to the cord of the ductus arteriosus; 8, ascending part or sinus of the arch covered at its commencement by the auricular appendix and pulmonary artery; 9, placed between the innominate and left carotid arteries; 10, appendix of the left auricle; 11, 11, the outside of the left ventricle, the lower figure near the apex.

larum, a partition which separates it from the left auricle. At the lower part of this septum, and just above the orifice of the inferior vena cava, is situated an oval depression named *fossa* or *fovea ovalis*, which is the vestige of the foramen ovale of the fœtal heart (*vestigium foraminis ovalis*), and indicates the original place of communication between the two auricles. It is bounded above and at the sides by a prominent border, which is deficient below, the *annulus ovalis* or *isthmus Vieussenii*. Continuous with the anterior inferior extremity of the annulus ovalis is a crescentic fold of endocardium, the *Eustachian valve*, springing from the anterior

margin of the inferior vena cava. This valve, which in the fœtus is proportionally large, and serves, in conjunction with the annulus ovalis, to direct the blood from the inferior vena cava through the foramen ovale, is in the adult comparatively small, and very variably developed, being often cribriform or perforated by numerous foramina, and sometimes reduced to a few slender filaments, or even altogether wanting. The mouth of the coronary vein is likewise protected by a semicircular valve, which is sometimes double, and which, though previously figured by Eustachius, is often named the *valve of Thebesius.* The coronary vein is considerably dilated before it enters the auricle, and this dilated portion, which has muscular parietes, is commonly termed the "coronary sinus." At the junction of the coronary vein with this dilated portion, there is a valve consisting of one or two segments. Other small veins likewise enter the coronary sinus, each of them protected by a valve.

The superior and inferior venæ cavæ being both directed somewhat towards the left side at their terminations, the wall of the auricle presents internally a convexity between them, which has received the somewhat misleading name of *tubercle of Lower.* In the human subject this elevation is slight, but in certain quadrupeds it is more strongly marked.

Running upwards from the fossa ovalis, under cover of the annulus, there sometimes exists a small slit, which leads beneath the annulus into the left auricle, forming thus an oblique and valved aperture between the two cavities. More rarely the foramen ovale of the fœtus remains so patent after birth as to interfere with the proper course of the circulation, and produce the pathological condition known as cyanosis—by the mixture of some dark or venous blood with the bright red or arterial blood of the left auricle.

2. The RIGHT OR ANTERIOR VENTRICLE extends from the right auricle towards the apex, and from the upper and anterior part of its base sends upwards, in front and to the left of the auriculo-ventricular opening, a smooth conical prolongation, free from columnæ carneæ, and named *infundibulum* or *conus arteriosus*: from the extremity of this prolongation of the ventricular cavity the pulmonary artery arises. The superficial wall of this ventricle, which is much thicker than that of the auricle, but thinner than that of the left ventricle, is formed by the part of the heart situated to the right of the anterior longitudinal groove, viz., the right border, the larger part of the anterior surface, and a part of the posterior. The internal or left wall is formed by the *septum ventriculorum*, and is convex, bulging to the right into the ventricle, so that a transverse section of the cavity presents a crescentic figure.

The *valve* guarding the right auriculo-ventricular opening is named the tricuspid valve, from the number of its segments. One of the segments, the smallest, is placed towards the left and rests upon the septum of the ventricles; the other two are placed more to the right,—one posteriorly against the right wall of the cavity, while the other, the largest of all, lying anteriorly, is interposed between the auricular and arterial openings, and has its ventricular surface directed forwards and upwards. The chordæ tendineæ arise chiefly from the musculi papillares, but some also from the walls of the ventricle and especially from the septum. Those arising from one papillary muscle or group of muscles run up in the angular interval between two adjacent segments of the valve, and, diverging from each other, are attached to both segments.

The semilunar valves at the root of the pulmonary artery are more

delicate than those which guard the aorta; and the sinuses of Valsalva are less strongly marked.

3. The LEFT AURICLE occupies the left and posterior part of the base of the heart. When distended, the atrium presents from behind, where it is best seen, a quadrilateral appearance. In front it rests against the aorta and pulmonary artery; behind, on each side, it receives two pulmonary veins, those from the left lung entering very close together; and on the right it is in contact with the other auricle. The *auricular appendage* is

Fig. 233.

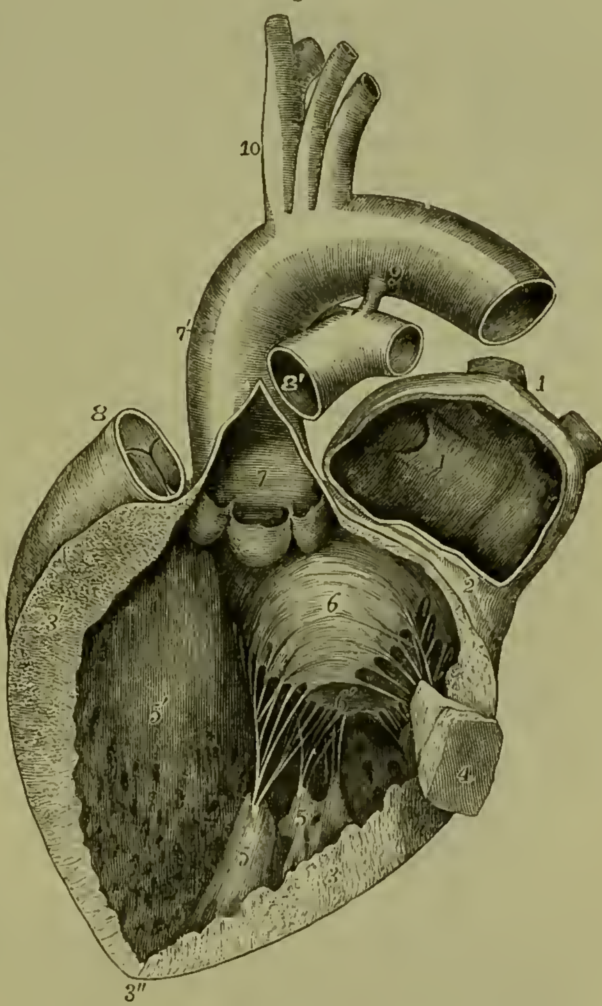


Fig. 233.—THE LEFT AURICLE AND VENTRICLE OPENED AND A PART OF THEIR ANTERIOR AND LEFT WALLS REMOVED SO AS TO SHOW THEIR INTERIOR. ½

The pulmonary artery has been divided at its commencement so as to show the aorta: the opening into the left ventricle has been carried a short distance into the aorta between two of the segments of the semi-lunar valves; the left part of the auricle with its appendix has been removed. The right auricle has been thrown out of view. 1, the two right pulmonary veins cut short: their openings are seen within the auricle; 1′, placed within the cavity of the auricle on the left side of the septum and on the part which forms the remains of the valve of the foramen ovale, of which the crescentic fold is seen towards the left hand of 1′; 2, a narrow portion of the wall of the auricle and ventricle preserved round the auriculo-ventricular orifice; 3, the left part, 3′, the right part towards the septum of the cut surface of the wall of the ventricle, seen to become very much thinner towards 3″, at the apex; 4, a small part of the anterior wall of the left ventricle which has been preserved with the principal anterior columna carnea attached to it; 5, 5, the large posterior columnæ carneæ; 5′, the left side of the septum within the cavity of the left ventricle; 6, the right or aortic segment, and 6′, the left or parietal segment of the mitral valve; 7, placed in the interior of the aorta near its commencement and above the three segments of its semilunar valve which are hanging loosely together; 7′, the exterior of the great aortic sinus; 8, the upper part of the conus arteriosus with the root of the pulmonary artery and its semilunar valves; 8′, the separated portion of the pulmonary artery remaining attached to the aorta by 9, the cord of the ductus arteriosus; 10, the arteries rising from the summit of the aortic arch.

the only part of the left auricle seen from the front: it extends forwards from the left side of the atrium, and curves towards the right side, resting

on the pulmonary artery. It is more curved than that of the right auricle, and its margins are more deeply indented.

The interior of the appendix presents musculi pectinati somewhat similar to those in the right side of the heart, but the walls of the sinus venosus are altogether smooth, and are also thicker than those of the right auricle. Posteriorly are the openings of the pulmonary veins, usually two on each side, and entirely without valves. The two veins of either or both sides sometimes unite into one before entering the auricle, whilst in other cases there is found an additional opening, most frequently on the right side. In the lower and fore part of the auricle is situated the left *auriculo-ventricular* orifice. It is of an oval form, and is rather smaller than the corresponding opening between the right auricle and ventricle. On the septum between the auricles, a slight lunated mark or depression may be observed, which is the vestige of the foramen ovale, as it appears upon the left side. The depression is limited by a slight crescentic ridge, the concavity of which is turned upwards, and which is in fact the now adherent border of a membranous valve, which during fœtal life is applied to the left side of the then open foramen ovale.

4. The LEFT OR POSTERIOR VENTRICLE occupies the left border of the heart, but only about a third of its extent appears on the anterior surface of the organ, the rest being seen behind. It is longer and narrower than the right ventricle, forming by itself the apex of the heart, as the right ventricle does not reach into that part. The cross section of its cavity is oval, not crescentic, the septum on this side being concave. Its walls, which, excepting near the

Fig. 234.

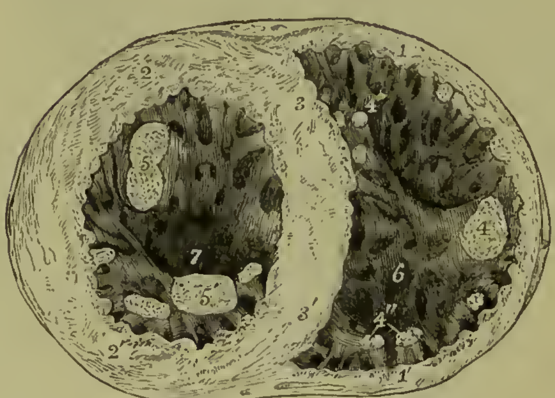


Fig. 234.—CROSS SECTION OF THE VENTRICULAR PART OF THE HEART AT TWO-THIRDS FROM THE APEX, LOOKING INTO THE CAVITIES. $\frac{2}{3}$

1, 1′, cut surface of the wall of the right ventricle; 2, 2′, the same of the left; 3, 3′, the same of the septum; 4, the principal columna carnea of the right ventricle on its right border; 4′, some of those on the septum near the front; 4″, some of those on the posterior wall near the septum; 5, the principal anterior columna carnea of the left ventricle; 5′, the largest of those situated posteriorly in the left ventricle; 6, the deepest part of the cavity of the right ventricle; 7, that of the left ventricle at the apex of the heart.

apex, are three times as thick as those of the right ventricle, are thickest at the part where the ventricle is widest, about one-fourth of its length from the base; from this point they become thinner towards the auricular opening, but they are still thinner towards the apex which is the weakest part. The lining membrane, which is continuous with that of the left auricle and the aorta, is usually less transparent than that of the right ventricle, especially in later life. In the interior of the cavity are noticed columnæ carneæ, musculi papillares with chordæ tendineæ, and two orifices guarded with valves. The *columnæ carneæ* are, on the whole, smaller than those of the right ventricle, but are more numerous and more densely reticulated.

Their intersections are very numerous near the apex of the cavity, and also along its posterior wall, but the upper part of the anterior wall and septum is comparatively smooth. The *musculi papillares* are collected into two bundles, which are larger than those of the right ventricle, and are formed one from the anterior, the other from the posterior surface of the ventricle. The two orifices of this ventricle are situated very close together, with one of the segments of the auriculo-ventricular valve between; the auriculo-ventricular opening being placed at the left and posterior part of the base of the ventricle, behind and to the left of that which leads into the aorta.

The *bicuspid* or *mitral* valve, which guards the auriculo-ventricular opening, resembles in structure the tricuspid valve of the right ventricle, but it is much thicker and stronger in all its parts, and consists of only two pointed divisions or segments, continuous at their attached bases. The larger of the two segments is suspended obliquely to the right and in front of the other, between the auricular and the aortic orifices: the smaller is situated to the left and posteriorly, and close to the wall of the ventricle. There is usually a smaller lobe at each angle of junction of the two principal segments, more apparent than those of the tricuspid valve.

One portion of the chordæ tendineæ from each musculus papillaris is distributed to half of one segment, and the other portion to the neighbouring side of the other segment, so that when the musculi papillares contract, and make the segments tense, they also cause their margins to approach each other. The chordæ tendineæ are stronger and less numerous than in the right ventricle.

The arterial or aortic orifice, circular in form, and smaller than the auriculo-ventricular, is placed in front and to the right of that opening, and very close to it, being separated from it only by the attachment of the anterior segment of the mitral valve. The semilunar valves which guard it are thicker and stronger than those of the right side of the heart, the lunulæ are more strongly marked off, and the central nodules, or *corpora Arantii*, are larger. The sinuses of Valsalva are more strongly marked at the mouth of the aorta than at the commencement of the pulmonary artery, and from the two anterior of them arise the right and left coronary arteries for the supply of blood to the substance of the heart.

Position of the Parts of the Heart with Relation to the Wall of the Thorax.

The exact position of the various parts of the heart is important in reference to auscultation. This subject has of late been carefully investigated by several anatomists; but there is still some discordance in their statements on some points, caused probably by the difficulty of marking with precision the situation of non-symmetrical viscera in artificially opened bodies, and in part perhaps by differences naturally existing among individuals. The following statement derived from Luschka is in general accordance with the results of others, with the exception, as remarked by Walshe, that most of the positions are fixed a little too high. Nearly two-thirds of the bulk of the heart lie to the left of the middle line. The upper edge of the auricles corresponds with a line extending across the sternum from the second right into the first left intercostal space. The auriculo-ventricular sulcus corresponds with a line which unites the sternal end of the fifth right costal cartilage with the second left intercostal space beneath the middle of the second costal cartilage. The rounded margin formed by the wall of the

left ventricle extends from the second left intercostal space to a point in the fifth space placed two inches vertically below the nipple. The sharp margin formed by the right ventricle passes from the sternal end of the fifth right costal cartilage, and crosses behind the end of the body of the sternum and the sixth left costal cartilage, to meet the other margin at the apex.

Fig. 235.

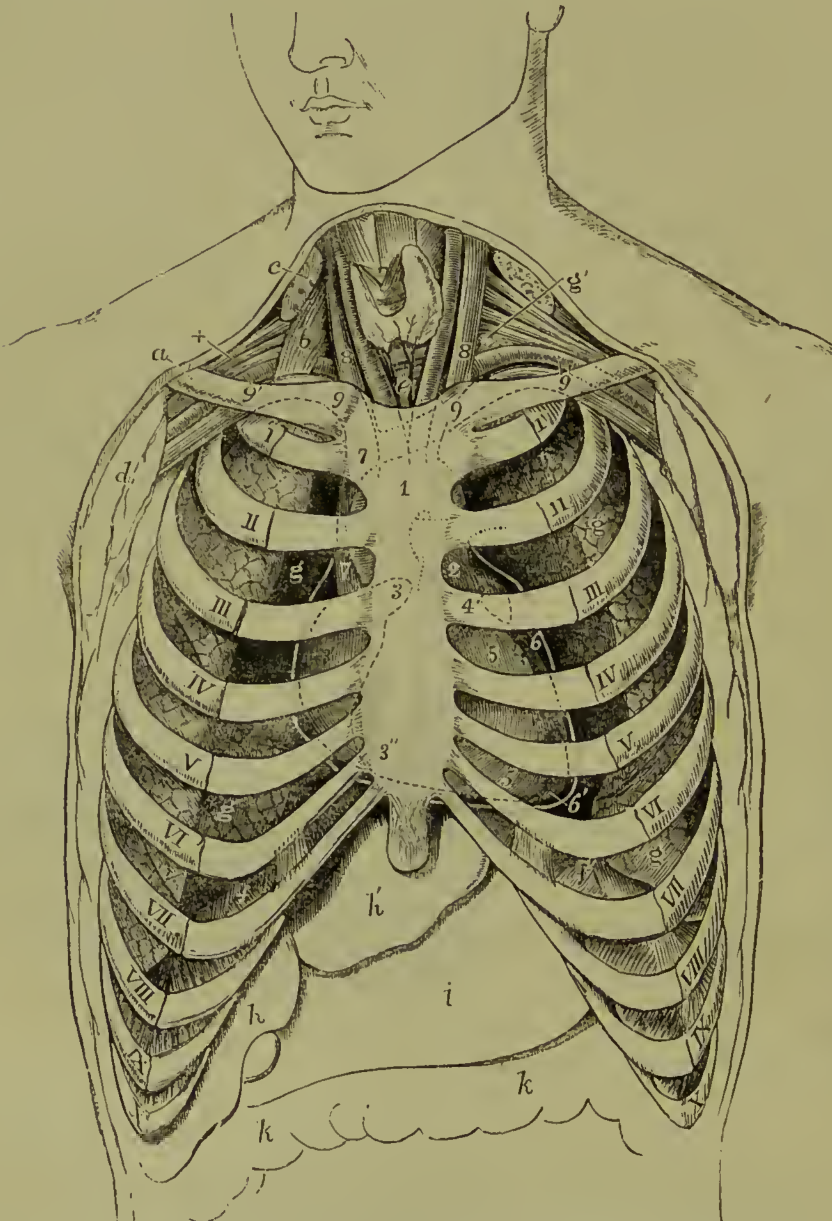


Fig. 235.—Semi-diagrammatic representation of the Chest, with the Intercostal Spaces dissected in front to show the position of the Heart and Great Vessels, as seen behind the Sternum and Costal Cartilages (from Luschka and A. Thomson).

a, right clavicle ; *b*, scalenus anticus muscle ; *c*, sterno-mastoid muscle divided ; *d*, pectoral muscles divided ; +, axillary nerves above the subclavian artery ; *e*, trachea below the isthmus of the thyroid body ; *f*, *f*, upper surface of the diaphragm ; *g*, *g*, surface of the lungs ; *g'*, on the left side, apex of the lung or pleura appearing in the neck ; *h*, right, *h'*, left lobe of the liver ; *i*, stomach ; *k*, *k*, transverse colon ; I, to X, first to tenth ribs near

their cartilages; 1, placed on the lower part of the manubrium of the sternum, and on the place of the arch of the aorta indicated by dotted lines; 2, placed in the second left intercostal space, on the stem of the pulmonary artery; 3, apex of the right auricle; 3', its most prominent part, behind the third space; 3'', its lower part at the junction of the sixth and seventh right costal cartilages with the sternum; 4, left auricular appendix; 5, 5, right ventricle; 6, left ventricle; 6', apex of the heart: the white line outside the heart is intended to indicate the external pericardium, as if the anterior half were removed by a transverse incision; 7, 7, vena cava superior; 8, 8, internal jugular veins; 9, 9, subclavian veins, joining the jugular; 9, 7, 9, innominate veins; the right rising behind the sterno-clavicular articulation, the left crossing obliquely behind the upper half of the manubrium. The position of the first parts of the innominate artery, left carotid and left subclavian arteries, is indicated behind and below this vein; 9', 9', outer part of the subclavian arteries. It is to be observed that in this figure the attachment of the sixth costal cartilage to the sternum is represented a little too high.

The auriculo-ventricular openings lie in the line of the auriculo-ventricular sulcus. The middle of that of the right side lies behind the sternum, between the fourth costal cartilages, and the anterior cusp of the tricuspid valve, and extends to the fifth left costal cartilage. The middle of the left auriculo-ventricular opening is in the second intercostal space, less than an inch to the left of the sternum; but as it is placed deeply, and overlaid by the arterial openings, the part immediately over it is unfavourable for auscultation, which is therefore best conducted at the point of impulse. The orifice of the pulmonary artery, according to Luschka, is placed immediately to the left of the sternum, opposite the second intercostal space, the free margin of the anterior valve reaching up to the lower border of the second rib. The aortic orifice, behind the insertion of the third left costal cartilage and the sternum, is on a slightly lower level than the orifice of the pulmonary artery, and is covered by it in two-thirds of its breadth. The aortic orifice being thus concealed, the sounds produced within it are best heard at the spot where the aorta approaches nearest to the surface, viz., opposite to the first and second intercostal spaces at the right margin of the sternum. (Luschka, Die Brustorgane, 1857; and Anatomie des Menschen, &c., 1863; Walshe, Diseases of the Heart and Great Vessels; Sibson, On the Normal and Abnormal Situation and Structure of the Viscera of the Chest, in Trans. of the Provinc. Med. and Surg. Assoc., vol. xii., year 1842, and in his Work on Medical Anatomy; Allen Thomson, Notice of the case of E. Groux, &c., with Observations on the Position and Actions of the Heart, in Glasgow Med. Journ. April, 1858.)

The following additional particulars are taken from the observations of Allen Thomson. The summit of the aortic arch is on a level with the middle of the manubrium sterni; and the left border of the innominate artery at its origin from the arch is slightly to the left side of the middle line. The middle of the commencement of the aorta, where it springs from the left ventricle, is behind the left border of the sternum, on a level with the lower edge of the third costal cartilage. The ascending part of the aorta bulges beyond the right border of the sternum to the extent of at least a quarter of an inch; and the vena cava superior extends about half an inch farther in the same direction. The trunk of the pulmonary artery is wholly to the left of the middle line, and its left border is about three quarters of an inch beyond the left border of the sternum. The concavity of the aortic arch is on a level with the junction of the manubrium with the body of the sternum.

The right auricular appendage covers the lower part of the ascending aorta to the right of the pulmonary semilunar valves, and its point is exactly behind the middle line on a level with the upper border of the third costal cartilages.

The most projecting part of the right ventricle with the conus arteriosus lies behind the sternum, between the lower end of the body and the inner part of the left third intercostal space.

The right auricle extends to fully an inch beyond the right border of the sternum,

The apex of the heart is situated about three and a-half inches to the left of the middle line, and in the fifth intercostal space. The apex of the left auricular appendage is in the lower part of the second intercostal space or behind the third costal cartilage, about an inch and a quarter from the left of the sternum.

FIBROUS AND MUSCULAR STRUCTURE OF THE HEART.

The heart consists chiefly of muscular tissue ; but besides this and the thin membranes investing its surface and lining its cavities, there enter into the formation of its wall, numerous blood-vessels, absorbents, and nerves, together with more or less fat and some areolar tissue.

The fibrous tissue belonging to the heart, besides what enters into the structure of the different valves and the chordæ tendineæ, is found principally surrounding the auriculo-ventricular and great arterial orifices. When we view the base of the heart so placed that the two auriculo-ventricular orifices, which are separated only by the upper edge of the septum ventriculorum are side by side, instead of the right being somewhat in front of the left, as is the case during life, the aortic opening is seen to occupy a position between and in front of them, and to have the opening of the pulmonary artery immediately in front of it. The wall of the aortic opening is firmly blended opposite one of the semilunar valves with the forepart of the right margin of the left auriculo-ventricular opening ; and opposite the angle between the other two valves it is in close contact with the margin of the right auriculo-ventricular opening. In the angle between the aortic and two auriculo-ventricular openings there is found a small fibro-cartilaginous mass, which in some large animals, as the ox and elephant, is replaced by a piece of bone. From this nodule a thick process extends backwards between the two auriculo-ventricular orifices beneath the septum auricularum, and others pass forwards forming bands, one on each side of the aortic opening. These processes form the bases of what have been elaborately described by authors as the *fibrous* or *tendinous rings* of the auriculo-ventricular openings. These rings, and others which are described as bounding the arterial orifices, have had a great importance imputed to them as being the tendons of origin of the ventricular muscular fibres, a view which, however, from recent investigations to be presently noticed, appears to be incorrect. The rings around the auriculo-ventricular orifices consist of only a small quantity of loose, white, fibrous tissue, continuous with that which is found in the segments of the valves, strengthened on the sides next the septum by the processes from the fibro-cartilaginous nodule. The rings of the arterial orifices have been described by authors, and also in the previous editions of this work, as each formed by a fibrous band or zone, one edge of which is even, and gives attachment to the muscular fasciculi of the ventricle, whilst the other is scalloped into three deep semilunar notches, and is firmly fixed to the middle coat of the large artery. This scalloped margin is simply the line of junction of the endocardium with the festooned line of attachment of the semilunar valves and termination of the artery, strengthened however by areolar tissue. The fibres of the middle coat of the artery also, opposite the sinuses of Valsalva, are not arranged annularly as in other parts of the vessel, but diverge from between the sinuses, and spread upwards and laterally on the walls of the vessel ; and the attachment of the artery to the ventricle is principally effected by fibrous tissue continuous with the middle coat of the artery and with the fibrous tissue in the valves, which spreads out between the small fasciculi of the muscular substance, and is firmly connected with it.

THE MUSCULAR FIBRES of the heart in their mode of action belong to the involuntary class, but are of a deep red colour, and possess the transversely striated structure. They are smaller than the ordinary voluntary muscular fibres: their striation is frequently as distinct in a longitudinal as in a transverse direction: and not only is there an exceedingly intricate interlacement of both fasciculi and fibres, but the latter appear to divide and unite frequently with each other so as to produce a finely reticulated structure.

Fig. 236.

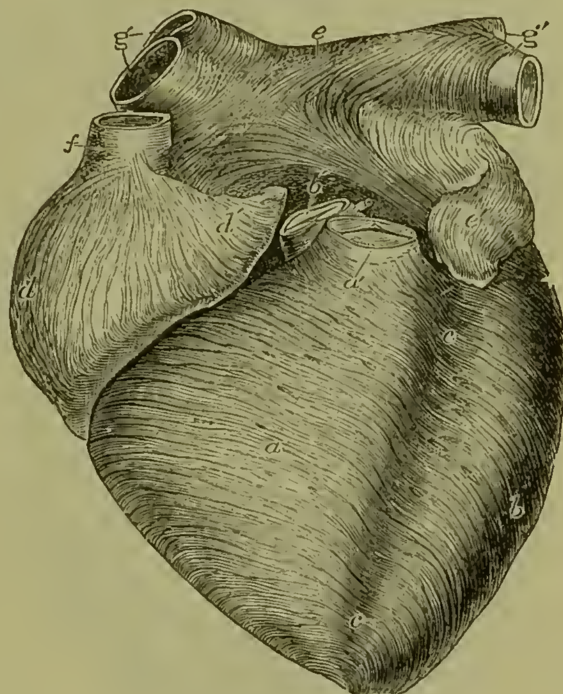


Fig. 236.—HEART OF A YOUNG SUBJECT DISSECTED AFTER BOILING TO SHOW THE SUPERFICIAL MUSCULAR FIBRES, SEEN ANTERIORLY. $\frac{2}{3}$

This figure is planned after one of Luschka's, but its details have been chiefly taken from an original preparation. The aorta and pulmonary arteries have been cut short close to the semilunar valves, so as to show the anterior fibres of the auricles. *a*, superficial layer of the fibres of the right ventricle; *b*, that of the left; *c*, *c*, anterior interventricular groove from which the coronary vessels have been removed, showing at the upper and lower part most of the fibres passing across from the right to the left ventricle, while in the middle part some dip into the septum; *a′*, pulmonary artery; *b′*, aorta; *d*, right auricle; *d′*, its appendix, both showing chiefly perpendicular fibres; *e*, upper part of the left auricle; between *e*, and *b′*, the transverse fibres which behind the aorta pass across both auricles; *e′*, appendix of the left auricle; *f*, superior vena cava, round which, near the auricle, circular fibres are seen; *g*, *g′*, right and left pulmonary veins with circular bands of fibres surrounding them.

The fibres of the auricles are not continuous with those of the ventricles, the two sets being connected together only by the intervention of the thin fibrous rings round the auriculo-ventricular orifices; so that when these rings are destroyed by boiling a heart for some hours, the auricles may be easily separated from the ventricles.

Fibres of the auricles.—These consist of a superficial set, common to both cavities, and of deeper fibres proper to each. 1. The *superficial* common or *transverse* fibres run transversely over both sinuses, near the base, and are most numerous on the anterior surface: some of them pass into the inter-auricular septum. The deeper fibres, which are *proper* to each auricle, consist of two sets, viz. the looped and the annular fibres. 2. The *looped* fibres pass over the auricle and seem to be attached by both extremities to the corresponding auriculo-ventricular rings. 3. The *annular* fibres encircle the auricular appendages from end to end, some longitudinal fibres running within them. These annular fibres also surround the entrances of the venæ cavæ on the right, and of the coronary vein and the pulmonary veins on the left side of the heart,—the muscular fibres extending for some distance

from the auricle upon the veins, especially upon the superior vena cava and the pulmonary veins.

Fibres of the ventricles.—The muscular fibres of the ventricles have a very intricate disposition, which has received great attention from various anatomists, such as Wolff, Gerdy, Reid, Searle, and most recently Pettigrew, the last of whom has done much to elucidate the nature of the arrangement in animals, although perhaps the whole subject cannot yet be considered as fully understood.

Fig. 237.

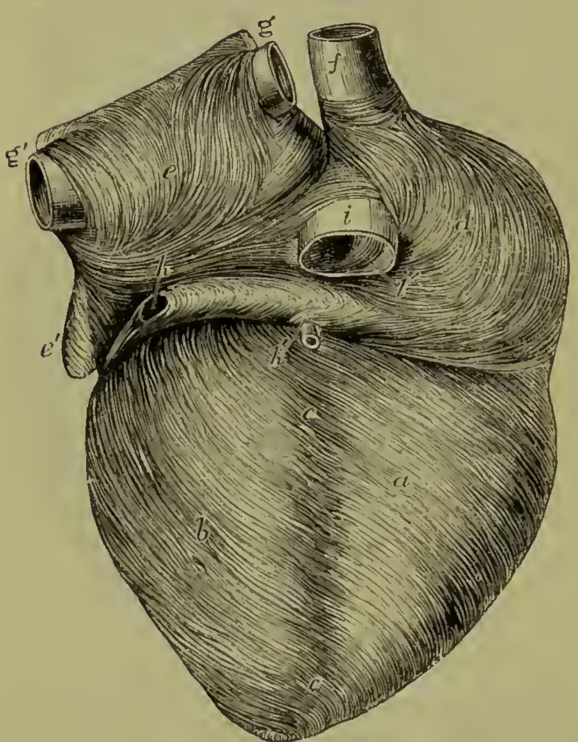


Fig. 237.—Posterior view of the same preparation as is represented in the preceding figure. $\frac{2}{3}$

a, posterior surface of the right ventricle with its superficial muscular fibres dissected; *b*, the same of the left ventricle; *c*, posterior interventricular groove, from which the coronary vessels have been removed; *d*, right auricle; *e*, the left, showing some transverse fibres common to both auricles, and some belonging to each one; *f*, superior vena cava; *g*, *g'*, pulmonary veins cut short; *h*, sinus of the great coronary vein covered by muscular fibres; *h'*, posterior coronary vein joining the principal one; *i*, inferior vena cava; *i'*, Eustachian valve as seen from behind.

It is chiefly the reticulated structure or continual union of the greater part of the muscular fibres with each other which renders difficult the investigation of the course and disposition of these fibres. In order to unravel them with any degree of success, it is best to boil the slightly distended heart for five or six hours, so as to destroy the connective tissue, and then carefully to dissect the heart in part by cutting and in part by tearing asunder the fibres with blunt instruments.

According to Pettigrew's observations, made principally upon the hearts of ruminating animals, as many as seven layers of fibres may be distinguished in the walls of both ventricles;* three of these being external, three internal, and one situated intermediately between them: but it may be remarked that, although some of these layers, such as the external, may be readily separated from the next, others of them run so much into those with which they are in contact, that we must regard the distinction of layers as applying more strictly to the difference of the direction of the majority of the fibres at different depths, than to a real and constant separation of determinate layers, in each of which the fibres are alike in direction. At the same time, for the convenience of description, it may be well to recognise provisionally the seven layers of Pettigrew.

One of the most important facts which has been established by Pettigrew's

* Wolff conceived that five or six layers might be made out.

researches, is that of the continuity of the fibres of certain external layers with those of corresponding internal layers. This continuity takes place at the base of the heart round the auriculo-ventricular orifices and upon the septum, and at the apex of the left ventricle in that peculiar spiral concentration of the fibres known to previous observers as the vortex or whorl. Thus the fibres of the first or external layer are continuous with those of the deepest or innermost, in part by folding over the margin of the auriculo-ventricular orifice, and in part by penetration through the apex. In the same manner the fibres of a second or deeper external layer are continuous with those of a layer named the sixth by Pettigrew, and the fibres of the third external layer with those of the fifth; while the fibres of the middle or fourth layer of Pettigrew may be considered to return upon others of the same set. In this manner the first and seventh layers enclose all the others, the second and sixth enclose those within them, and the third and fifth enclose the fourth.

The fibres of the ventricles, therefore, do not take their origin, as was in general previously held, from the fibrous rings surrounding the auriculo-ventricular orifices

Fig. 238.

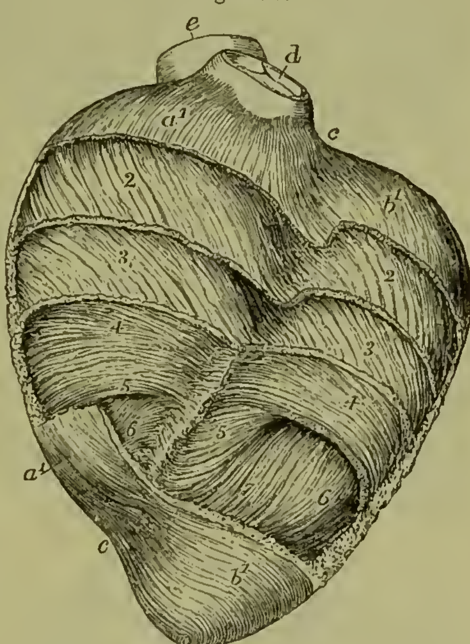


Fig. 238.—View of a Partial Dissection of the Layers of Fibres of the Ventricles in a Sheep's Heart in Front (after the manner of Pettigrew). $\frac{2}{3}$.

At the base and apex the pericardium and connective tissue and fat alone have been removed, and the superficial layer of fibres is displayed on these parts of both ventricles. In the intervening space, layer after layer of the fibres has been removed from above downwards, reaching to a greater depth on the left than on the right side. a^1, a^1, the superficial layer of the right ventricle; b^1, b^1, the same of the left ventricle; 2, the second layer of both ventricles; 3, the third; 4, the fourth or central, with fibres nearly transverse; 5 and 6, two of the deeper layers coming next; and 7, a small part of the fibres of the deepest layer on the front of the left ventricle, passing into one of the larger papillary muscles, and derived from the posterior superficial fibres, which have entered the whorl of the apex anteriorly; the different degree of obliquity and other changes of direction of the fibres is shown in these several layers; *c*, *c*, between these letters and numbers is the anterior coronary or interventricular groove, in which superiorly the greater part of the fibres of the superficial layer is seen to cross from right to left; in the remaining part of the groove, which is dissected, part of the fibres from both ventricles is seen to turn backwards towards the septum; *d*, the pulmonary artery cut short; *e*, the first prat of the aorta.

and the roots of the great arteries. The only fibres which come in contact with those structures are the fibres of the superficial layer, where they dip in to be continuous with those of the deepest layer; and even these for the most part exhibit, on careful dissection, no breach of continuity of muscular fibres, but are merely bound down by white tissue penetrating between the fasciculi; a small portion, however, of the muscular fibres which surround the auriculo-ventricular orifices become continuous with the segments of the valves and with chordæ tendineæ, and through them with the musculi papillares, the fibres of which belong chiefly to the innermost layer.

Some fibres, especially those belonging to the superficial layers, and more especially upon the posterior surface of the heart, pass round and enclose both ventricles; others, especially in front, may be considered to belong to one ventricle only. Thus the anterior superficial fibres of the right ventricle in descending from the right to the

left of the heart, pass in part across the anterior longitudinal groove, covering partially the coronary vessels, and in part dip into the groove and ascend obliquely upon the right side of the septum. The anterior fibres of the left ventricle are derived in part from those arising from the roots of the great vessels, in part from those crossing the coronary groove from the right, and in part they come out from the left surface of the septum, into which they dip in front like those of the right ventricle: those of the anterior fibres of the left ventricle which are near the apex pass spirally round this part to enter the whorl posteriorly, while the posterior set of superficial fibres, turning round the apex with a similar spiral, arrive in front and there enter the vortex. These fibres thus carried into the interior ascend upon the posterior and anterior

Fig. 239.

Fig. 239.—View of the Fibres of the Sheep's Heart, dissected at the apex to show the "Vortex" in which the fibres enter the apex in two sets from the External Layer (from Pettigrew).

a, *a*, anterior fibres entering the apex of the left ventricle posteriorly at *b*; *c*, *c*, posterior fibres entering the apex anteriorly at *d*.

internal surfaces of the left ventricle, forming the almost longitudinal innermost layer of fibres, and contribute to form the columnæ carneæ and musculi papillares. Their direction, as they ascend internally, is nearly the opposite of that in which they made their descent externally.

The direction of the fibres in the successive layers gradually changes as we proceed from without inwards; for example on the front of the right or left ventricle it is at first very oblique from right to left of the heart, or indeed in some parts almost longitudinal from base to apex,* it then becomes less and less oblique, until in the middle layer, which is also the thickest, it is transverse; the obliquity, being now resumed and gradually increasing, the direction is changed to that from right to left of the heart and from apex to base upwards, until at last in the interior it is extremely oblique, or nearly longitudinal.

Fig. 240.

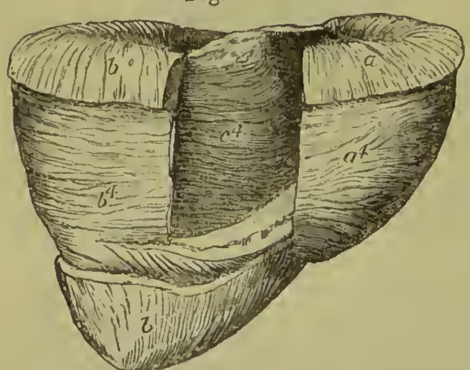


Fig. 240.—Dissection of the Ventricles of the Sheep's Heart, viewed from behind, a part of the Posterior Wall being removed to show a Dissection of the Fibres of the Septum at a similar depth (from Pettigrew). $\frac{2}{3}$

a, the superficial layer of fibres of the right ventricle; *b*, the same of the left ventricle at the base and apex posteriorly; a^4, the fourth or middle layer of fibres of the right ventricle exposed; b^4, the same layer of the left ventricle; c^4, the same of the septum, showing the fibres of that layer continued forward from those of the left ventricle.

It is only the three outer layers and part of the fourth layer which are distributed round both ventricles, the three internal layers belong solely to each ventricle.

The septum consists of three sets of fibres, viz., 1, those belonging to the right ventricle; 2, those belonging to the left; and 3, those common to both ventricles.

The difference of thickness of the walls of the right and left ventricles, which is so

* The direction is less longitudinal in the human heart than in that of the sheep.

remarkable in the adult, does not exist at an early period in the fœtus. An examination of the fœtal heart, therefore, shows a much greater similarity in the mode of arrangement of the layers of fibres in the walls of the two ventricles than might be supposed from the examination of the adult.

It is to be observed, in conclusion, that Pettigrew's observations were made almost exclusively upon the hearts of animals. No doubt many circumstances are nearly similar in the human heart, but it is still desirable that a fuller examination of the structure of the human heart should be made, and more especially that this subject should be investigated in connection with its development.

(C. F. Wolff, De ordine fibrarum Muscularium Cordis; Act. Acad. Petropol. 1780—1792. Gerdy, Rech. &c. d'Anatomie, Paris, 1823. J. Reid, Art. "Heart," in Cyclop. of Anat. and Physiol. Searle, Art. "Fibres of the Heart," in the same. J. Pettigrew, in Philos. Trans. 1864.)

VESSELS AND NERVES.

The bloodvessels and nerves of the heart will only be shortly noticed in this place, as a fuller description of them will be given along with those parts of the vascular and nervous systems from which they respectively take their origin.

Vessels.—The substance of the heart receives its blood through the two *coronary arteries*, which arise respectively from the two anterior aortic sinuses of Valsalva. The *coronary veins* terminate in the right auricle. Besides the great cardiac or coronary vein, and another principal branch, there are two smaller orders of veins opening separately into the right auricle. The stems and larger divisions of these vessels run principally in the great transverse and longitudinal grooves of the heart; from these grooves and other parts of the external surface the smaller branches penetrate into every part of the muscular substance.

Nerves.—The nerves given off by the cardiac plexuses, appear rather small in comparison with the bulk of the heart; they are derived partly from the cerebro-spinal and partly from the sympathetic system, more especially from the pneumogastric nerve, and from the cervical and superior dorsal ganglia of the sympathetic nerve. Besides the larger ganglia in the cardiac plexuses at the base of the heart, the nerves present minute ganglia at different points along their course in its substance, which have been figured and described by Remak. The nerves course obliquely downwards on the ventricles of the heart, decussating with the superficial fibres, between which and the pericardium are situated their main branches and the ganglia of Remak. (Remak; Froriep's Notizen, 1838, p. 137; and Müller's Archiv. 1844, p. 463, taf. xii.)

WEIGHT AND DIMENSIONS OF THE HEART.

The size and weight of the heart, the thickness of its walls, the capacity of its several cavities, and the width of its great orifices, have been made the subject of extensive observation, more especially with the view to determine some standard dimensions with which to compare the deviations occurring in disease.

Size.—It was stated by Laennec, as the result of his experience, that the heart in its natural condition was about equal in size to the closed hand of the individual. It is about five inches long, three and a half in its greatest width, and two and a half in its extreme thickness from the anterior to the posterior surface; but linear measurements of a flaccid organ like the heart must be subject to so many accidental variations as to render them of little value.

Weight.—The average weight of the heart in the adult is also subject to considerable variation, ranging between rather wide limits, which depend on the general weight of the body and on the sex.

Its mean weight has been variously stated by different authors, as from 7 oz. up to 10 oz.; but according to tables published by Reid, the average weight in the adult male is as high as 11 oz., and in the female as 9 oz.; while according to Peacock the average of the male is 9¾ oz., and that of the female 9 oz.

The weight of the heart maintains some general proportion to that of the body. According to Tiedemann this is about 1 to 160; by Clendinning it was found to be 1 to 158 in males, and 1 to 149 in females; and by Reid to be 1 to 169 in a series of thirty-seven males, and 1 to 176 in twelve females; but in the healthy males dying suddenly the ratio was as 1 to 173.

It was shown by Clendinning that the heart continued to increase in weight up to an advanced period of life, but at a comparatively slower rate subsequently to the age of twenty-nine years. Subjoined is a tabular statement of some of the average results derived from the observations of these authors.

CLENDINNING.

Age in years.	Weight in oz. Males.	Females.
15 to 29	$8\frac{1}{2}$	$8\frac{1}{7}$
30 — 50	$9\frac{1}{2}$	$8\frac{1}{2}$
50 — 60	$10\frac{1}{6}$	8
60 — +	$10\frac{1}{2}$	8

	REID.		PEACOCK.	
	Weight in oz. and drachms.			
Age in years.	Males.	Females.	Males.	Females.
16 to 20	8 10	6 13	8 $2\frac{2}{3}$	8 $1\frac{2}{3}$
20 — 30	10 4	8 0	9 $0\frac{1}{7}$	8 $10\frac{1}{7}$
30 — 40	10 8	9 3	9 7	8 $13\frac{1}{5}$
40 — 50	11 7	9 8	8 11	9 3
50 — 60	11 10	9 14	9 12	9 $7\frac{1}{3}$
60 — 70	12 6	9 5	10 $13\frac{1}{3}$	7 0
70 — +	12 6	9 6		

Entirely in accordance with these observations upon the increase of the heart's weight according to age, it has been found by Bizot that this organ continues to enlarge in all its dimensions as life advances, viz., in the length, breadth, and thickness of its walls. The greatest increase was detected in the substance of the left ventricle and the ventricular septum. (Reid, in the Lond. and Edin. Monthly Journal of Med. Science, April, 1843; T. B. Peacock, in the same journal, in 1846, and reprinted separately, with additional observations, in 1854; Clendinning, in the Medic. Chir. Transact., 1838; Bizot, Mém. de la Soc. Médic. d'Observation de Paris, tom. i. p. 262. 1836.)

Capacity of the auricles and ventricles.—To determine with precision the absolute and relative capacities of the four cavities of the heart, as they exist during life, is impossible; and their capacity is so much influenced by their different states of distension, and also by the different degrees of contraction of their muscular walls at the moment of death, that no constant numerical relation in this respect can be looked for between them. Hence the most opposite statements prevail, especially with regard to the size of the ventricular cavities.

The auricles are generally admitted to be rather less capacious than the ventricles. The right auricle is also said to be larger than the left, in the proportion of 5 to 4. (Cruveilhier.)

The capacity of the left ventricle has been stated by different anatomists as variously as at $1\frac{1}{2}$ fluid ounces and 4 oz.; it probably does not exceed 2 oz.

The right ventricle is asserted by some to be larger than the left; by others (Lower, Sabatier, Andral) the two are stated to have an equal capacity; Cruveilhier, judging from the effect of injections, has found the left to be the larger of the two. In the ordinary modes of death, the right ventricle is always found more capacious than the left, which is probably owing to its being distended with blood, in consequence of the cessation of the circulation through the lungs: the left ventricle, on the other hand, is found nearly empty, and thus becomes more fully contracted. There are reasons for believing, however, that during life scarcely any difference of capacity exists between the two cavities.

Size of the ventricular openings.—The right auriculo-ventricular opening, and the orifice of the pulmonary artery, are both found to be somewhat larger after death than the corresponding openings on the left side of the heart. Their circumference is thus stated by Bouillaud. (Traité des Malad. du Cœur, tom. i. p. 52. Paris, 1835.)

		Inches and Lines. Max.	Med.	Min.
Auriculo-ventricular orifices	Right	4 0	3 10	3 9
	Left	3 10	3 6	3 3
Arterial orifices	Right (Pulmonary)	2 10	2 7	2 6
	Left (Aortic)	2 8	2 8	2 4

According to Peacock's most recent observations, the following (omitting the

fractions of lines) are the average dimensions of these orifices in adult males and females, between the ages of 20 and 60 years :—

		Males.		Females.	
		Inches and Lines.			
Auriculo-ventricular orifices	Right	4	6	4	0
	Left	3	7	3	10
Arterial orifices	Right (Pulmonary)	3	4	3	3
	Left (Aortic)	3	0	2	10

DEVELOPMENT OF THE HEART AND GREAT BLOOD-VESSELS.

The Heart.—The heart first appears as an elongated sac or dilated tube lying at the fore part of the embryo, having two veins connected with it behind, and a large arterial trunk proceeding from it in front. This tube exhibits rhythmic contractions of its walls from a very early period. Its form is at first symmetrical, but soon it becomes curved or bent upon itself like a horse-shoe, and projects on the ventral aspect of the body towards the right side.

Fig. 241.

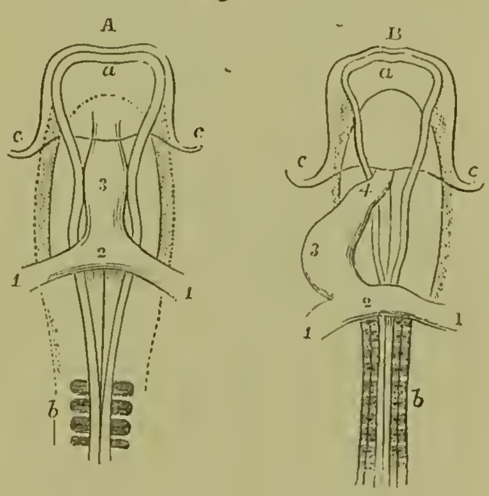


Fig. 241.—Views of the anterior or cephalic half of the Embryo-Chick from the Abdominal Surface, showing the Heart in the earliest stages of its formation (after Remak). Magnified about twenty times.

A, embryo after about twenty-eight or thirty hours of incubation ; B, after about thirty-six hours of incubation ; *a*, placed on the anterior cerebral vesicle ; *b*, the primitive cervical vertebræ ; *c*, *c*, the cephalic fold of the germinal membrane ; 1, 1, primitive veins entering the auricle ; 2, 3, in A, the primitive and simple sac or short tube of the heart ; in B, 2, the auricular part ; 3, the ventricular part beginning to bulge or be bent to the side and dilate ; 4, the anterior part of the tube which becomes the aortic bulb.

As this bending increases the venous end approaches the arterial, and at the same time the tube, which progressively increases in size and in the thickness of its walls, becomes divided by two slight constrictions into three compartments, opening successively into each other. The first, next to the veins, is the *auricular* portion, the middle one is the *ventricular*, and the last, which is the primitive arterial trunk, is named the *bulbus arteriosus.*

The auricular portion becomes placed behind the ventricular compartment, and relatively to that cavity considerably enlarged. Moreover, two little pouches appear upon it, one at each side, which form the future auricular appendages. The walls of the ventricular portion are already thicker than the rest.

The next series of changes consists in the gradual subdivision of the single auricle, ventricle, and arterial bulb, each into two compartments, to form the right and left auricles, the right and left ventricles, and the pulmonary artery and aorta : and these changes are accompanied by an alteration in the position of the parts with relation to the body, the ventricular portion now lying transversely, so as to bring that portion which is afterwards to form the apex towards the left side.

This subdivision commences first in the single *ventricular* portion of the heart. A small notch appears externally to the right of the apex, which goes on increasing in depth for some weeks, and then is again gradually obliterated. In the meantime, about the fourth or fifth week, a septum begins to rise up internally from the right side of the heart, at a little distance from the apex and from the anterior wall of the cavity, and proceeds in the direction of the base, towards the arterial bulb, and about the eighth week is complete. Traces of the subdivision of the *auricular* portion com-

Fig. 242.

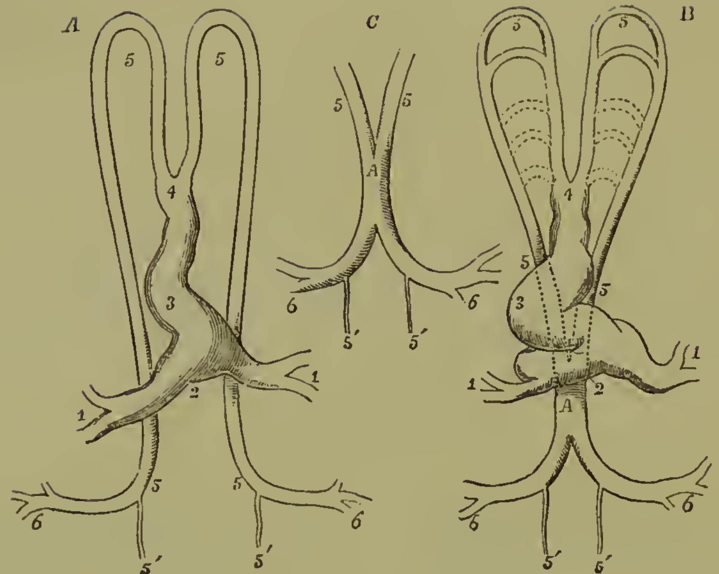


Fig. 242.—Diagrammatic Outlines of the Heart and First Arterial Vessels of the Embryo, as seen from the Abdominal Surface.

A, at a period corresponding to the 36th or 38th hour of incubation in the chick; B, and C, at the 48th hour of incubation; 1, 1, primitive veins; 2, auricular part of the heart; 3, ventricular part; 4, aortic bulb; 5, 5, the primitive aortic arches, and their continuation as descending aorta; these vessels are still separate in their whole extent in A, but at a later period, as shown more fully in C, have coalesced into one tube in a part of the dorsal region; in B, below the upper 5, the second aortic arch is formed, and farther down the dotted lines indicate the position of the succeeding arches to the number of five in all; 5′, 5′, the continuation of the main vessels in the body of the embryo; 6, 6, the omphalo-mesenteric arteries passing out of the body of the embryo into the vascular area of the germinal membrane.

mence early in the form of a slight constriction on the outer surface, which marks off the future auricles, the left being at first the smaller of the two; but the auricular septum is not begun until after that of the ventricles is completed. About

Fig. 243.

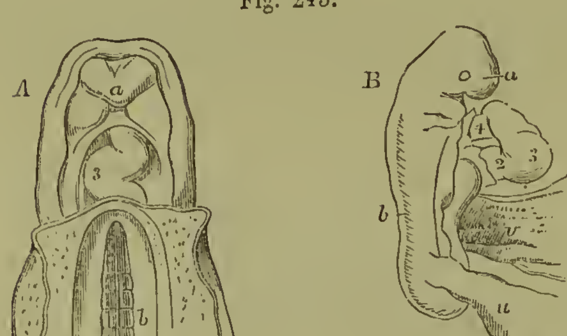


Fig. 243.—Human Embryoes at different early stages of development, showing the Heart in its tubular condition.

A, upper half of the body of a human embryo of three weeks, viewed from the abdominal side (from Coste); *a*, frontal plate; *b*, vertebræ, on which the primitive aortæ are lying; 3, the middle of the tube of the heart, below it the place of entrance of the great veins, above it the aortic bulb.

B, lateral view of a human embryo more advanced than that last referred to, and somewhat imperfectly developed (from A. Thomson); *a*, the frontal part of the head; *b*, the vertebral column; *v*, the wide communication of the umbilical vesicle or yolk sac with the intestine; *u*, communication with the allantois or urachus; 2, auricular part of the heart connected with the veins posteriorly; 3, ventricular part of the bent tube; 4, the aortic bulb; near the extremities of the tube the divided pericardium is seen.

the ninth week it appears, growing from above and behind downwards and forwards, and at length comes to meet and coalesce below with the rising edge of the inter-

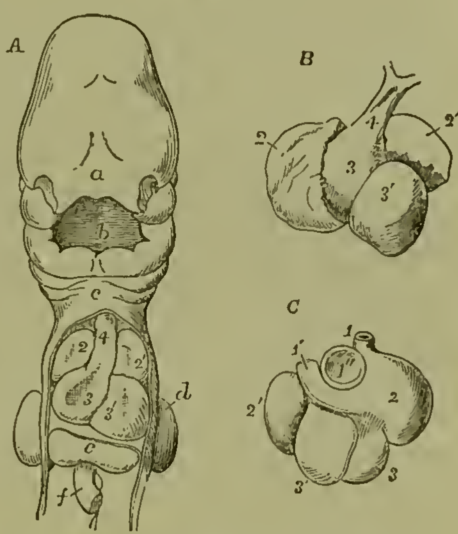


Fig. 244.—Shows the position and form of the Heart in the Human Embryo from the Fourth to the Sixth week.

A, upper half of the body of a human embryo said to be four weeks old (from Kölliker after Coste); B and C, anterior and posterior views of the heart of a human embryo of six weeks (from Kölliker after Ecker); *a*, frontal lappet; *b*, mouth; *c*, below the lower jaw and in front of the second and third branchial arches; *d*, upper limb; *e*, liver; *f*, intestine cut short; 1, superior vena cava; 1′, left superior cava or brachio-cephalic connected with the coronary vein; 1″, opening of the inferior vena cava; 2, 2′, right and left auricles; 3, 3′, right and left ventricles; 4, aortic bulb.

ventricularseptum. The interauricular septum, however, remains incomplete during intrauterine life, and leaves an opening in the middle, which forms the *foramen ovale.* The farther steps in the separation of the auricles are connected with the changes which take place at the entrances of the great veins. There are now three large vessels terminating in the auricular extremity of the heart; of these two correspond with the superior and the inferior vena cava, and the third is the great coronary vein. At first, after the interauricular septum is partly formed above, the inferior cava opens directly into the left auricle, which is the smaller of the two; but about the twelfth week a septum, *the valve of the foramen ovale,* which afterwards forms the floor of the fossa ovalis, rises up on the left side of the entrance of the vein, which thus comes to open into the right auricle; whilst at the same time the separation of the two auricles is also rendered more complete by the gradual advance of the valve over the foramen ovale, leaving, however, the passage open until after birth.

Another valvular fold is developed at an early period on the right and anterior border of the orifice of the inferior cava, between it and the auriculo-ventricular orifice; this is the Eustachian valve. It appears to continue the opening of the inferior cava towards the upper margin of the foramen ovale, and directs the blood of the vein through that passage.

The left auricle has at first no connection with the pulmonary veins. The manner in which this connection is afterwards established has not yet been ascertained.

Originally the heart is composed of a mass of nucleated cells, similar in character to those which primarily constitute the other organs of the body. Muscular tissue is subsequently formed from these cells; but the rhythmic contractions commence and proceed for some time, whilst the heart is yet composed of cells, and before the muscular fibres have been developed.

The great vessels.—At first the bulbus arteriosus is divided into two arches, which pass upwards and outwards one on each side, then turn downwards and form a right and left root of the aorta, which are at first separate, but afterwards unite behind the heart and in front of the vertebral column to form the single stem of the descending aorta. The distance soon elongates between those arches and the arterial bulb, and four other pairs of arches appear in series from above downwards, passing outwards from the vessel which ascends to the first arch, and opening into that which descends from it. Thus there are on each side *five arches,* an *internal* or *anterior* trunk uniting the origins of the arches, and an *external* or *posterior* trunk uniting their terminations, and continued into one of the *roots of the aorta.* These vascular arches are placed each in one of the branchial processes of the dorsal plates (p. 64), but it is to be noted that the whole five arches do not co-exist; for the highest

disappear before the last are developed. This arrangement of blood-vessels, together with the originally single condition of the heart, corresponds to a certain extent with the permanent condition of the heart and branchial arteries in fishes; with this difference as regards the vascular arches in the human fœtus and that of mammals, birds and scaly reptiles, that they never present any farther branchial subdivision.

As the interventricular septum is approaching the base of the heart, that is, about the seventh or eighth week, the arterial bulb becomes also divided by an internal partition, meeting from opposite sides, into two vessels, which are slightly twisted on each other, and are so adjusted as to become connected, the anterior with the right and the posterior with the left ventricle: these vessels afterwards constitute the commencement of the pulmonary artery and of the aorta. A furrow subsequently, beginning on the outside, completes the separation into two vessels.

Whilst the arterial bulb is thus converted into the commencement of the pulmonary artery and aorta, the five vascular arches arising from it undergo a metamorphosis, by which the permanent aorta with the brachio-cephalic vessels and the pulmonary arteries are formed. The general results of this change have been observed by several embryologists, but it has not yet been made out with certainty in all its details.

It is generally admitted, however, that the fourth arch on the left side (counting from above), which receives blood from the aortic division of the bulb, is persistent, and, continuing to enlarge, eventually becomes the arch of the aorta. The fourth arch on the right side, as well as the first, second, and third arches on both sides, are obliterated to a greater or less extent, while certain portions of them, remaining pervious and connected with the aortic arch, appear to form the commencement of the great vessels rising from it.

Both the arches of the fifth pair were held by Baer to be connected with the

Fig. 245.

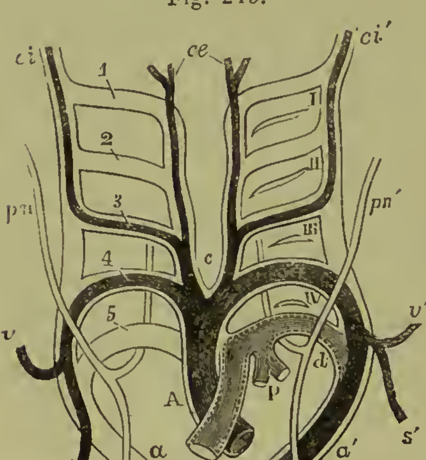


Fig. 245.—Diagram of the Aortic or Branchial Vascular Arches of the Mammal, with their transformations giving rise to the permanent Arterial Vessels (according to Rathke).

A, P, primitive arterial stem or aortic bulb, now divided into A the ascending part of the aortic arch, and P the pulmonary; *a*, the right; *a'*, the left aortic root; A', the descending aorta. On the right side 1, 2, 3, 4, 5, indicate the five branchial primitive arterial arches; on the left side, I, II, III, IV, the four branchial clefts, which, for the sake of clearness, have been omitted on the right side. It will be observed, that while the fourth and fifth pairs of arches rise from the part of the aortic bulb or stem, which is at first undivided, the first, second, and third pairs are branches above *c*, of a secondary stem on each side. The permanent systemic vessels are represented in deep shade, the pulmonary arteries lighter; the parts of the primitive arches, which have only a temporary existence, are drawn in outline only. *c*, placed between the permanent common carotid arteries; *ce*, the external carotid arteries; *ci*, *ci'*, the right and left internal carotid arteries; *s*, the right subclavian rising from the right aortic root beyond the fifth arch; *v*, the right vertebral from the same opposite the fourth arch; *v'*, *s'*, the left vertebral and subclavian arteries rising together from the left or permanent aortic root opposite the fourth arch; P, the pulmonary arteries rising together from the left fifth arch; *d*, the outer or back part of the left fifth arch, forming the ductus arteriosus; *pn*, *pn'*, the right and left pneumogastric nerves, descending in front of the aortic arches, with their recurrent branches represented diagrammatically as passing behind, with a view to illustrate the relations of these nerves respectively to the right subclavian artery and the arch of the aorta and ductus arteriosus.

pulmonary division of the bulb, and to send ramifications into the lungs, so as to form the right and left branches of the pulmonary artery respectively: the farther or distal portion of the right arch being obliterated, while the corresponding part of the left side continued open, as the *ductus arteriosus*, until birth. According to this view, the third arch on each side is persistent as the subclavian artery, and the external trunk above this remains as the vertebral artery, and the internal as the carotid; while the internal trunk between the third and fourth arches of the right side becomes the innominate artery. In so far as it applies to birds and some reptiles this view may be correct. But a different view of the metamorphosis, as it occurs in mammalia and man, has more recently been presented by Rathke, which has been adopted by Kölliker and others, and probably is more consistent with truth. According to Rathke, in man and mammalia one arch only, viz., the left fifth, is concerned in the formation of the pulmonary arteries; and the fifth arch of the right side is entirely obliterated. From the fifth left arch a branch is given off, which, together with the proximal part of the arch, forms the pulmonary artery, and which divides into the primary branches for the right and left lung, the distal part of the arch being converted, as according to Baer's theory, into the ductus arteriosus. The fourth arch of the right side, according to Rathke, forms the commencement of the right subclavian artery; a branch is given off opposite the external extremity of the fourth arch on both sides, which forms on the right side the remainder of the right subclavian, and on the left the whole of that artery; the vertebral arteries are derived from the subclavians external to the system of arterial arches; the internal trunks in their extent between the third and fourth arches remain as the common carotids, and in the remainder of their extent form the external carotids, while the third arches and the external trunks above them are converted into the internal carotid arteries. (Baer, Entwicklungsgeschichte, 1839; Rathke, Untersuchungen über die Aortenwurzeln, &c. Vienna, 1857, and Müller's Archiv. 1843, p. 276; A. Thomson, Edin. New Philos. Journal, 1830-31, and Edin. Med. and Surg. Journ., No. 140; Ecker, Icones Physiologicæ; Bischoff's works; Kölliker, Entwicklungsgeschichte. 1861).

Peculiarities of the Fœtal Heart and Great Vessels.—Fœtal Circulation.

Position.—The fœtal heart, even after all its parts are formed, continues to be placed vertically in the thorax until about the fourth month, when the apex begins to turn towards the left side, so as to give it an oblique position.

Fig. 246.

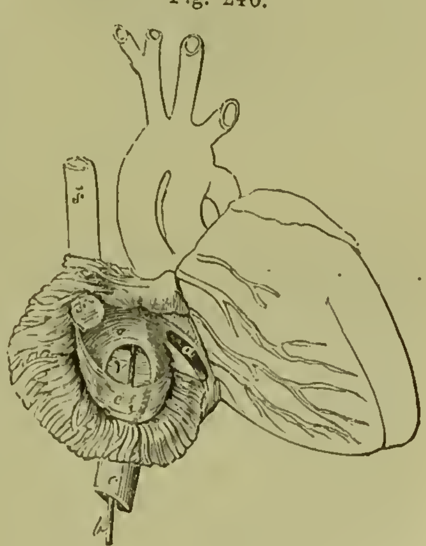


Fig. 246.—View of the Front and Right Side of the Fœtal Heart, at four months, the right Auricle being laid open (from Kilian).

a, the right auriculo-ventricular opening; *b*, a probe passed up the vena cava inferior and through the foramen ovale into the left auricle; *c*, vena cava inferior; *c*, Eustachian valve; *v*, valve of the foramen ovale; *s*, *s′*, vena cava superior.

Size.—As compared with the body, the heart is very much larger in the early fœtus than at later periods or subsequently to birth. At one time, indeed, it occupies nearly the whole thoracic cavity. At the second month the proportion of its weight to that of the body is said by Meckel to be 1 to 50; but the ratio becomes gradually reduced to that of 1 to 120 at birth. In the adult the average is about 1 to 160.

For a long period the auricular portion is larger than the ventricular, and the right auricle is more capacious than the left; but towards birth these peculiarities disappear,

and the ventricular portion becomes the larger part of the heart. As to the ventricles themselves, the right is at first the smaller; afterwards it becomes the larger of the two, and at birth their size is about equal. In the right ventricle the infundibulum is at first less marked than afterwards.

Structure.—For a time the walls of the ventricles are, comparatively speaking, very thick, and the thickness of both is nearly the same. In approaching the full period, however, the left begins to be the thicker of the two. But the two chief differences in the internal structure of the fœtal heart from that of the adult are the communication which exists between the two auricles by the foramen ovale, and the large size of the Eustachian valve.

The large oval orifice named the *foramen ovale* is placed at the lower and back part of the auricular septum, and is said to attain its greatest size at the sixth month. It becomes gradually occluded by a valvular fold already alluded to, which ascends from below and behind, and rises up on the left side of the rim of the foramen ovale. This rim becomes continuous at the sides with the valve, but above its free margin, which is concave and turned upwards, the foramen is left open. At length the valve passes for some distance beyond the upper part of the foramen; and still, owing to its position on the left side of the opening, it permits the passage of blood from the right to the left auricle. In the reverse direction, however, it closes the opening and no blood can pass.

Fig. 217.

Fig. 217.—View of the Posterior and left surface of the Heart of a Fœtus of four Months, the left Auricle being opened (from Kilian).

a, left auriculo-ventricular orifice; *c*, inferior vena cava, through which a probe *b*, is passed from below, and thence by the foramen ovale into the left auricle; *e*, left auricular appendage laid open; *o*, valve of the foramen ovale seen to be attached to the left side of the annulus ovalis of the septum.

The pulmonary artery of the fœtus, in leaving the right ventricle, first gives off the branch to the right lung, and then appears to divide into its left branch and the short but wide tube named *ductus arteriosus*. This vessel, which is nearly as wide as the pulmonary artery itself, is of the thickness of a goose-quill at the time of birth, and about half an inch long. It conducts the chief part of the blood of the right ventricle into the aorta, which it joins obliquely within the termination of the arch, a little beyond the origin of the left subclavian artery.

Besides the usual branches of the descending aorta intended to supply the abdominal viscera and the lower limbs, two large vessels, named hypogastric or *umbilical arteries*, are prolonged from the common iliacs, and passing out of the abdomen, proceed along the umbilical cord, coiling round the umbilical vein, to reach the placenta. The commencement of each of these vessels afterwards forms the trunk of the corresponding internal iliac artery, and, from their size, they might be regarded in the fœtus as the continuations of the common iliac arteries into which the aorta divides. From the placenta the blood is returned by the umbilical vein, which, after entering the abdomen, communicates by one branch with the portal vein of the liver, and sends another, named *ductus venosus*, to join the vena cava inferior, as will be more fully described in the account of the vessels of the liver.

Course of the blood in the fœtus.—The right auricle of the fœtal heart receives its blood from the two venæ cavæ and the coronary vein. The blood brought by the superior cava is simply the venous blood returned from the head and upper half of

the body; whilst the inferior cava, which is considerably larger than the superior, conveys not only the blood from the lower half of the body, but also that which is sent back in a purified state from the placenta through the umbilical vein. This latter stream of blood reaches the vena cava inferior, partly by a direct passage—the ductus venosus, and partly by the hepatic veins after circulating through the liver in the venæ portæ.

The blood of the superior vena cava, descending in front of the Eustachian valve, and mixed with a small portion of that from the inferior cava, passes on into the right ventricle, and is thence propelled into the trunk of the pulmonary artery. A small part of it is then distributed through the branches of that vessel to the lungs, and returns by the pulmonary veins to the left auricle; but by far the larger part passes through the ductus arteriosus into the aorta, entering that vessel beyond the place of origin of the arteries of the head and upper limbs, and, mixed probably with a small quantity of the blood flowing along the aorta from the left ventricle, descends partly to supply the lower half of the body and the viscera, but principally to be conveyed along the umbilical arteries to the placenta. From all these parts it is returned by the vena cava inferior, the venæ portæ, and the umbilical vein; and, as already noticed, reaches the right auricle through the trunk of the inferior cava.

The blood of the inferior vena cava is only in small part distributed with that of the superior cava; by far the larger portion, directed by the Eustachian valve through the foramen ovale, flows from the right into the left auricle, and thence, together with the small quantity of blood returned from the lungs by the pulmonary veins, passes into the left ventricle, from whence it is sent into the arch of the aorta, to be distributed almost entirely to the head and upper limbs. A small portion of it, however, probably flows on into the descending aorta and joins the large stream of blood from the ductus arteriosus. From the upper half of the body the blood is returned by the branches of the superior cava to the right auricle, from which its course has been already traced.

Sabatier was of opinion that no mixture of the two streams of blood from the two venæ cavæ took place in the right auricle, but that all the blood of the inferior cava passed into the left auricle and ventricle, whilst that of the superior cava reached the right ventricle. He thought, however, that the two kinds of blood were intermixed at the junction of the ductus arteriosus with the aorta. The entire separation of the two streams of blood of the venæ cavæ, as supposed by Sabatier, is not generally admitted in the mature fœtus; but there is reason to believe that it does take place in earlier stages. In fact, the inferior cava, as already mentioned, at first opens into the left auricle, and must therefore convey its blood immediately into that cavity. As the fœtus approaches maturity, more and more of the blood of the inferior cava joins the stream from the superior cava; and, indeed, the course of the blood, and the relative position of the veins, as well as other original peculiarities of the fœtal heart, become gradually altered, to prepare the way as it were for the more important changes which take place at birth. It seems also probable that very little of the blood propelled from the left ventricle passes into the descending aorta beyond the ductus arteriosus.

From the preceding account of the course of the blood in the fœtus, it will be seen, that, whilst the renovated blood from the placenta is principally conveyed to the upper or cephalic half of the fœtus, the lower half of the body is chiefly supplied with the blood which has already circulated through the head and upper limbs, exhibiting in this a certain analogy with the mode of circulation in the turtle and various other reptiles. The larger portion of this latter stream of blood, however, is again sent out of the body to be changed in the placenta. This duty is principally performed by the right ventricle, which after birth is charged with an office somewhat analogous, in having to propel the blood through the lungs. But the passage of the placental blood is longer than that of the pulmonary, and the right ventricle of the fœtus, although probably aided by the left in the placental circulation, also takes a large share in the systemic circulation through the lower half of the body; and this, perhaps, may be the reason why the right differs less in thickness from the left ventricle in the fœtus than in the adult.

Changes after birth.—The immediate changes which take place at birth consist of the sudden stoppage of the placental circulation and the simultaneous commence-

Fig. 248.

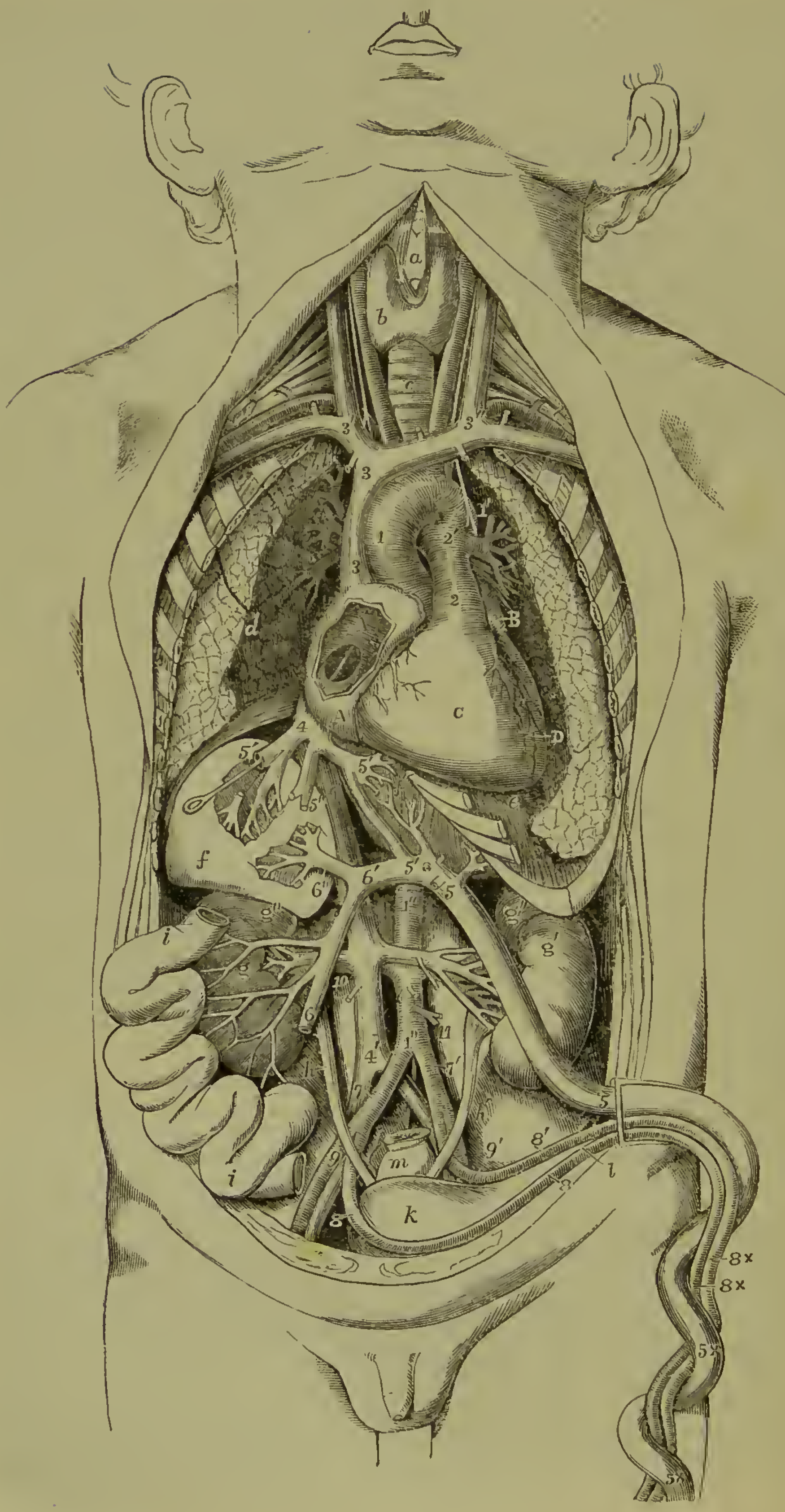


Fig. 248.—Semi-diagrammatic view of the Organs of Circulation in the Fœtus from before, (modified from Luschka and from Nature). $\frac{2}{3}$

a, front of the thyroid cartilage; *b*, right side of the thyroid body; *c*, trachea; *d*, surface of the right lung turned outwards from the heart; *e*, diaphragm below the apex of the heart; *f*, right lobe of the liver, dissected to show ramifications of the portal and hepatic veins; *f′*, the middle part and left lobe of the liver in the same manner, showing branches of the umbilical veins and ductus venosus; *g*, right, *g′*, left kidney; *g″*, supra renal bodies; *h*, right, *h′*, left ureter; *i*, portion of the small intestine turned towards the side, to show the veins from it going to the portal vein; *k*, urinary bladder; *l*, is placed below the umbilicus, which is turned towards the left of the fœtus, and points by a line to the urachus; *m*, rectum, divided and tied at its upper part.

A, *A*, right auricle of the heart opened to show the foramen ovale: a probe, introduced through the large divided right hepatic vein and vena cava inferior, is seen passing through the fossa ovalis into the left auricle: at the lower part of the fossa ovalis is seen the Eustachian valve, to the right and inferiorly the auriculo-ventricular orifice; *B*, the left auricular appendix; *C*, the surface of the right ventricle; *D*, placed on the inner surface of the left lung, points to the left ventricle.

1, ascending part of the arch of the aorta; 1′, back part beyond the ductus arteriosus; 2, stem of the pulmonary artery; 2′, the place of division into right and left pulmonary arteries and root of the ductus arteriosus: the left pneumo-gastric nerve is seen descending over the arch of the aorta; 3, superior vena cava; 3′, right, 3″, left innominate vein; 4, stem of the inferior vena cava, between the junction of the hepatic vein and the right auricle; 4′, continuation of the vena cava inferior below; 5, umbilical vein within the body of the fœtus; 5 ×, without the body, in the umbilical cord; 5′, 5′, ductus venosus; between 5 and 5′, the direct branches of the umbilical vein to the liver; 6, vena portæ; 6′, its left branch joining the umbilical vein; 6″, its right branch; 7, placed on the right iliac vein, points to the right common iliac artery; 7′, left common iliac artery; 8, right, 8′, left umbilical arteries coming from the internal iliac arteries; 9, 9′, external iliac arteries; 10, placed below the right renal vessels; 11, inferior mesenteric artery, above the root of which are seen the two spermatic arteries.

ment of an increased flow of blood through the lungs, which then perform their office as respiratory organs. The foramen ovale, the ductus arteriosus, the ductus venosus, and the umbilical vessels, all parts peculiar to the fœtus, are gradually closed, and the right and left cavities of the heart thenceforth cease to communicate directly with each other. According to Bernt, the ductus arteriosus begins to contract immediately after several inspirations have taken place: in three or four days he sometimes found it closed; on the eighth day it was obliterated in one half the cases examined, and on the tenth day in all. The foramen ovale appears to continue open a little longer, and it sometimes remains more or less so throughout life, as already stated. The umbilical arteries, the umbilical vein and the ductus venosus shrink and begin to be obliterated from the second to the fourth day after birth, and are generally completely closed by the fourth or fifth day.

PULMONARY VESSELS.

PULMONARY ARTERY AND VEINS.

The *pulmonary artery* is a short wide vessel, which carries the dark blood from the right side of the heart to the lungs. It arises from the infundibulum or conus arteriosus of the right ventricle, and passes for the space of nearly two inches upwards, and at the same time backwards and to the left side, to reach the concavity of the aortic arch, where it divides into its right and left branches. The mode of attachment of the pulmonary artery to the base of the ventricle has already been fully noticed. At each side of its commencement is the corresponding coronary artery springing from the aorta, and close to its sides are the two auricular appendages. It is at first in front of the aorta, and conceals the origin of that vessel; but higher up, where it lies in front of the left auricle, it crosses to the left side of the ascending aorta, and is finally placed beneath the transverse part of the arch. The pulmonary artery and the aorta are united together

by connective tissue and by the serous layer of the pericardium, which for the space of about two inches forms a single tube around both vessels. Rather to the left of its point of bifurcation it is connected to the under side of the aortic arch by means of a short fibrous cord, which passes obliquely upwards, backwards, and to the left. This is the remains of the ductus arteriosus, a large vessel peculiar to the fœtus, which has been already described.

The *two branches* of the *pulmonary artery.*—The *right branch*, longer and somewhat larger than the left, runs almost transversely outwards behind the ascending aorta and the superior vena cava into the root of the right lung, where it immediately begins to divide in the usual manner of arteries. The *left branch*, shorter than the right, passes horizontally in front of the descending aorta and left bronchus into the root of the left lung, to undergo its ramification.

The right and left pulmonary arteries, at the root of the lung, both lie in front of the bronchus and behind the veins. On the right side the bronchus is highest and the veins lowest, while on the left side the bronchus sinks to a level between the artery and veins.

Pulmonary Veins.—The *pulmonary veins*, which convey the red blood back from the lungs to the left side of the heart, ultimately converge into *four* short venous trunks, which are found, two on each side, in the root of the corresponding lung. The two veins of the *right* side, which are longer than those of the left, pass below the right pulmonary artery, and behind the superior vena cava, the right auricle, and the aorta, to enter the left auricle. Not unfrequently a third smaller vein exists on the right side. The two *left* pulmonary veins run a shorter course to reach the auricle, passing in front of the descending aorta.

SYSTEMIC VESSELS.

ARTERIES.

THE AORTA.

The aorta, the large main trunk of the systemic arteries, is situated partly within the thorax and partly in the abdomen. It commences at the left ventricle of the heart, and after arching over the root of the left lung, descends in front of the vertebral column, and passing through the diaphragm into the abdominal cavity, ends opposite the fourth lumbar vertebra, by dividing into the right and left common iliac arteries. In this course the aorta forms a continuous undivided trunk, which gradually diminishes in size from its commencement to its termination, and gives off larger or smaller branches at various points. Different parts of the vessel have received particular names, derived from their position or direction :—the following are generally recognized, viz., the *arch of the aorta*, the *thoracic aorta*, and the *abdominal aorta*. The short curved part, which reaches from the ventricle of the heart to the side of the third dorsal vertebra, is named the *arch;* the straight part, which extends from that vertebra to the diaphragm, is called the *thoracic* aorta ; and the remainder of the vessel, down to its bifurcation, is designated the *abdominal* aorta.

Arch of the Aorta.

The arch of the aorta commences at the upper part or base of the left ventricle of the heart, behind the pulmonary artery. At first it passes upwards and to the right side, somewhat in the direction of the heart

itself, and crosses obliquely behind the sternum, approaching at the same time more nearly to that bone. Having gained the level of the upper

Fig. 249.

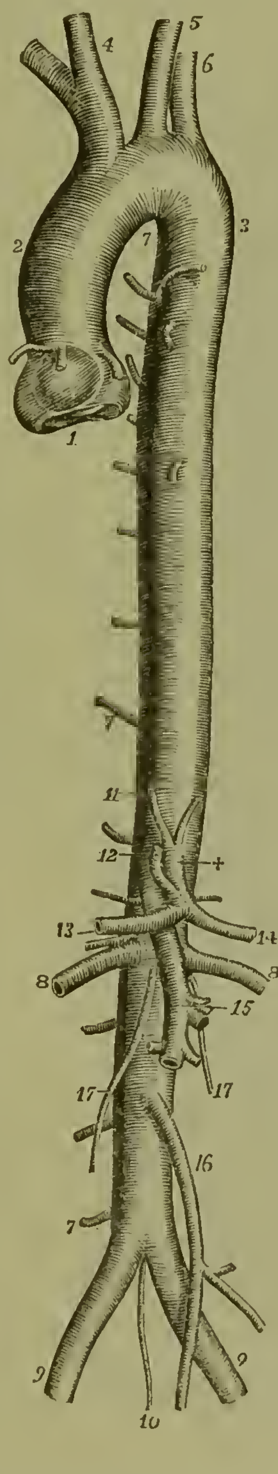


Fig. 250.

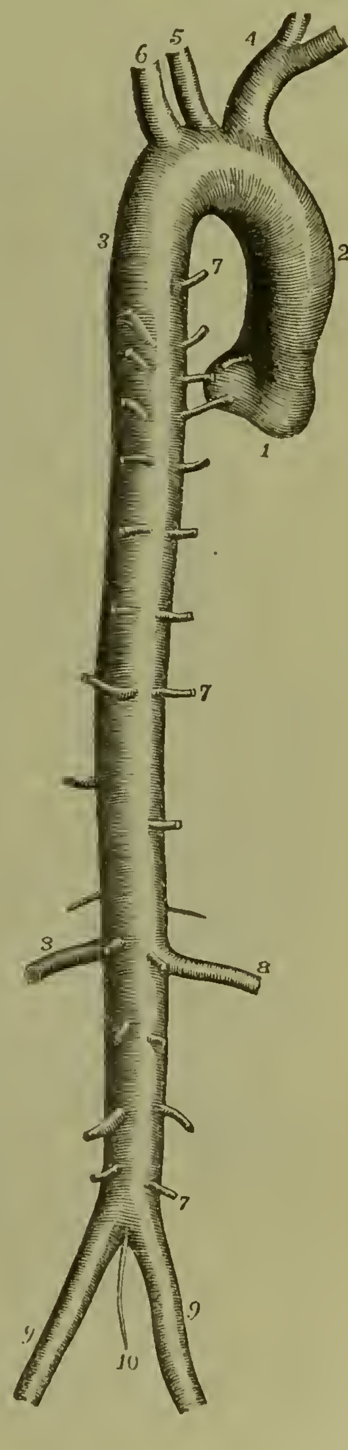


Fig. 249.—View of the Aorta from before, with the first part of its principal branches dissected out of the Body (from R. Quain). $\frac{1}{4}$

1, commencement of the aorta at the place where it has been separated from the left ventricle, showing below the semilunar valves closed, in front and at the sides the dilatations corresponding to these valves, or sinuses of Valsalva, and above these the origin of the right and left coronary arteries; 2, the ascending part of the arch, with the dilatation termed sinus of the arch; 3, the back of the arch, or termination of its descending portion; 4, innominate artery; 5, left carotid; 6, left subclavian; 7, hollow of the arch, and farther down the aorta, 7, 7, indicate two out of the series of intercostal arteries: the œsophageal arteries are also seen rising from the front of the thoracic aorta; 8, 8, right and left renal arteries; 9, 9, right and left common iliac arteries; 10, middle sacral artery; 11, marks one of the inferior diaphragmatic arteries; +, the cœliac axis; 12, the gastric artery; 13, the hepatic; 14, the splenic; 15, superior mesenteric; 16, inferior mesenteric; 17, right and left spermatic arteries.

Fig. 250.—View of the Aorta from behind, with its principal branches (from R. Quain). $\frac{1}{4}$

The numbers have the same signification as in Fig. 249. The origin of the right and left intercostal arteries close to each other and near the middle of the aorta posteriorly is shown.

border of the second costal cartilage of the right side, the vessel alters its course, and is directed upwards, backwards, and to the left side, then directly backwards, in contact with the trachea, to the left side of the body

Fig. 251.

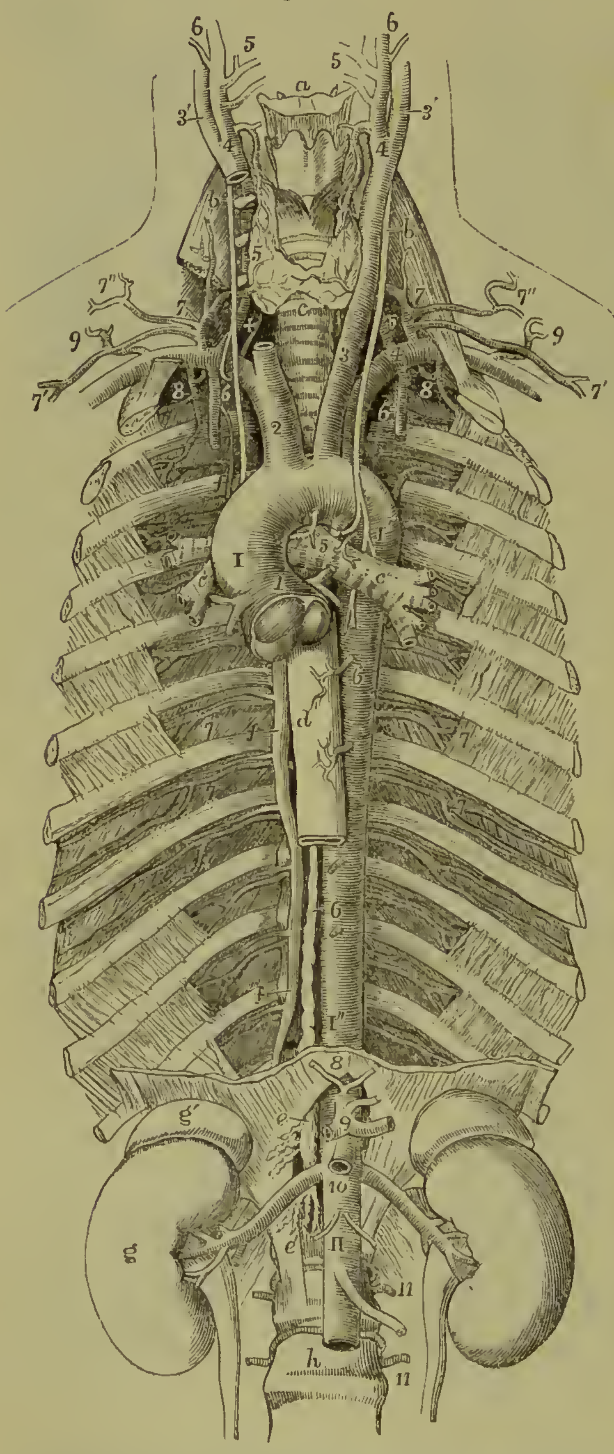


Fig. 251.—View of the Thoracic and upper part of the Abdominal Aorta, showing their relations and principal branches; together with a sketch of the first parts of the Carotid and Subclavian Arteries. ¼

The first ribs have been removed in front of the attachment of the scalenus anticus muscles, and are supposed to be drawn somewhat apart; the rest of the ribs down to the eleventh are divided, along with the intercostal muscles, at some distance outside their angles; the internal intercostal muscles are left in all the spaces excepting the seventh and eighth, in which they are removed so as to expose the external layer. The diaphragm has been cut transversely near its crura, and the part left behind is supposed to be stretched upwards and to the sides.

a, the front of the hyoid bone; *b*, placed on the anterior scalene muscles, points to the upper part of the pneumogastric nerves; *c*, the trachea below the isthmus of the thyroid gland, and lower down the same letter is on the left bronchus; *c′*, one of the divisions of the right bronchus emerging from behind the aorta; in the hollow of the aortic arch, above 5, are seen the cord of the ductus arteriosus cut short, and the left recurrent nerve passing below the arch; +, is placed on the right side between the recurrent nerve and the vertebral artery as they pass upwards; *d*, the œsophagus; *e*, upon the right crus of the diaphragm, and farther down *e′*, mark the receptaculum chyli of the thoracic duct, and its commencement by the lumbar plexus of lymphatic vessels and efferent mesenteric lacteal vessels; *f*, on the third, seventh, and eleventh ribs, points to the vena azygos and superior intercostal

veins of the right side ; *g*, kidney, *g′*, suprarenal body ; *h*, body of the fourth lumbar vertebra.

I, sinus of the aortic arch or ascending part of the arch : below this the semilunar valves are seen closed and distended by injection ; *I′*, posterior part of the arch, upon which the left pneumo-gastric nerve is seen descending ; *I″*, descending thoracic part of the aorta ; *II*, abdominal aorta emerging from between the crura of the diaphragm and descending to near its termination.

Branches of the arch and thoracic aorta ; 1, right and left coronary arteries ; 2, innominate ; 3, left carotid ; 4, left subclavian ; 5, bronchial arteries ; 6, 6, œsophageal arteries : the lower figure points by a line to the thoracic duct ; 7, intercostal arteries, marked in the sixth and seventh intercostal spaces.

Branches of the abdominal aorta ; 8, inferior diaphragmatic arteries cut short ; 9, cœliac axis with the gastric, splenic, and hepatic arteries cut short ; 10, placed on the aorta below the superior mesenteric artery (cut short) and the origin of the renal arteries ; a little below this the origin of the spermatic arteries ; below *II*, the inferior mesenteric artery, 11, 11, two of the lumbar arteries.

Branches of the carotid arteries ; the greater part of the right carotid artery has been removed to show the ascent of the vertebral artery in the canal of the transverse processes ; + is placed between the vertebral artery and the recurrent laryngeal nerve ; 3′, internal carotid artery ; 4, commencement of the external carotid artery ; close to this the superior thyroid artery is given off, which is seen descending to the larynx and thyroid body ; 5, the lingual and facial arteries ; 6, continuation of the external carotid, &c.

Branches of the subclavian arteries ; on the right side the middle part of the scalenus anticus muscle is removed ; on the left the figure 4 is placed close to the origin of the four following vessels ; 5, vertebral ; 6, internal mammary ; 7, thyroid axis ; 7′, its supra scapular branch ; 7″, its transverse cervical branch ; 8, superior intercostal artery, supplying two spaces on the right side and one on the left, rising in common with the deep cervical which turns upwards behind the subclavian artery ; 9, a posterior scapular artery rising from the third part of the subclavian.

of the second dorsal vertebra. Arrived at that point, it bends downwards, inclining, at the same time, a little towards the middle line; and at the lower border of the body of the third dorsal vertebra, on its left side, the arch terminates in the descending portion of the vessel. At its origin, the arch of the aorta is larger than elsewhere, and presents externally three small bulgings of nearly equal size, corresponding with the dilatations which form the *sinuses of Valsalva* or *of the aortic valves*, already described with the heart. Two of these sinuses are placed anteriorly and one posteriorly, and in the two anterior sinuses are seen the orifices of the two coronary arteries of the heart, the first branches given off by the aorta.

From the difference in the direction and connections of different portions of the arch it is described as consisting of an *ascending*, a *transverse*, and a *descending* portion.

The *ascending* portion of the arch of the aorta is placed at its commencement behind the sternum, on a level with the lower border of the third costal cartilage of the left side ; and it rises as high as the upper border of the second costal cartilage of the right side. Its length is about two inches or two inches and a quarter ; and its direction is curved.

In most cases there exists along the right side a dilatation, named the *great sinus of the aorta*. This dilatation varies in size in different bodies, and occasionally is not to be detected.

This portion of the aortic arch is enclosed in the pericardium, and, together with the pulmonary artery, is invested by a fold of the serous layer of that bag, in such a manner that both vessels are covered by the serous membrane, except where they are in contact with each other.

At its commencement the ascending part of the arch is concealed by the pulmonary artery, and by the right auricular appendage which overlaps it ; but, further up, the aorta passes to the right side and the pulmonary artery

to the left, and thus the aorta comes into view. It approaches very near to the sternum, from which it is separated only by the pericardium, by some connective tissue, and by the remains of the thymus gland lodged in the mediastinal space : higher up, the descending vena cava lies on the right side, and the pulmonary artery passes backwards on the left ; while behind are placed the right branches of the pulmonary vessels.

The second or *transverse* part of the arch is covered on the left side by the left pleura and lung, and is placed immediately in front and to the left of the trachea, before its bifurcation into the bronchi: it touches likewise the œsophagus posteriorly. The upper border of the transverse part of the arch has in contact with it the left innominate vein ; and from it are given off the large arteries (innominate, left carotid, and left subclavian), which are furnished to the head and the upper limbs. The lower or concave border overhangs the bifurcation of the pulmonary artery, and is connected with the left branch of that artery by the remains of the ductus arteriosus. At or near its end this part of the arch is crossed in front by the left vagus and phrenic nerves, with some offsets of the sympathetic ; and the recurrent laryngeal branch of the vagus turns upwards beneath and behind it.

The *descending* portion of the arch rests against the left side of the body of the third dorsal vertebra, and is covered by the left pleura. To the right side of this part of the arch is the œsophagus with the thoracic duct.

Branches.—The branches given off from the arch of the aorta are five in number. Two of these, named the *coronary* or cardiac arteries, comparatively small, arise from two of the sinuses of Valsalva, and are distributed to the walls of the heart. The other three are large primitive trunks, which supply the head and neck, the upper limbs, and, in part, the thorax, and usually arise from the middle or highest part of the arch, in the following order :—first, the *innominate* or *brachio-cephalic* artery, which soon subdivides into the *right subclavian* and the *right carotid* arteries ; second, the *left carotid ;* and, third, the *left subclavian* artery. The origin of the left carotid artery is usually somewhat nearer to the innominate artery than it is to the subclavian artery of its own side.

Peculiarities.—(For more extended information on the peculiarities of the aorta and of the blood-vessels in general, the student is referred to "The Anatomy of the Arteries," by Richard Quain, London, 1844.)

I. *Peculiarities of the Arch itself.*

Variations in height.—The arch sometimes reaches very nearly as high as the top of the sternum. Occasionally it has been found an inch and a half below that level, and in rare instances as much as three inches below it.

Double arch.—This very rare variety has been known to occur in two forms. In both of these the trachea and œsophagus passed through the circle formed by the two divisions of the arch, which united behind them. In one form the arch retained its inclination to the left side; the pulmonary artery, placed in its proper position, was united to the left division of the aorta by the obliterated ductus arteriosus; and from each division of the arch two branches arose, the carotid and subclavian. In the other form a symmetrical ring was completed by the two divisions, each giving rise to three vessels—subclavian, and external and internal carotid; while the pulmonary artery dipped into the circle from above, and sent out its branches beneath it.

Right arch.—Arching of the aorta to the right side has been observed to occur in three different forms. 1st. Accompanying total transposition of the heart and viscera. 2nd. Occurring without transposition of other parts, and with the left innominate artery, right carotid, and right subclavian given off in succession. 3rd. Occurring, in like manner, without transposition of other parts, its first branch being

the left common carotid, the second the right common carotid, the third the right subclavian, and the fourth the left subclavian, passing behind the œsophagus to reach its destination.

II. *Peculiarities affecting the Primary Branches.*

The situation of the branches.—Instead of springing from the highest part of the arch, the branches are frequently moved altogether to the right, and take origin from the commencement of the transverse portion, or even from the end of the ascending portion of the arch. In the ordinary arrangement the origin of the left carotid is nearer to the innominate than to the left subclavian; but the branches sometimes arise at equal distances from each other, or are unusually widely apart. A very frequent change consists in the approximation of the left carotid towards the innominate artery.

The number and arrangement of the branches.—These are extremely various. The most frequent change met with is their *reduction to two*, from the left carotid being united in a common trunk with the innominate artery. In cases of rare occurrence, the carotid and subclavian arteries of the left side, as well as those of the right, are conjoined in an innominate artery.

On the other hand, the number of the primary branches has been found to be *augmented* to four, by the separation, as it were, of the innominate artery into the right carotid and subclavian arteries, both arising directly from the aorta. In those cases, the right subclavian artery is most frequently the last branch given off, proceeding from the back part of the arch, and passing behind the œsophagus to reach its destination; but sometimes it is given off in its proper order, as the first branch, and in rare instances, it has been the second or third branch given off, in which case it has passed behind those which preceded it, to reach the limb.

In those instances in which the right subclavian is the last vessel given off, and in some other abnormal arrangements, a small pouch-like dilatation is sometimes found on the arch, which is a vestige of the right aortic root, and is accounted for by the changes in development which have led to the unusual disposition of the branches.

A remarkable variety is on record, in which the aorta divided at once into two vessels, as is the usual arrangement in some quadrupeds, all the arteries for the head, neck, and upper limbs, taking origin by a single trunk. In those cases the single trunk referred to passed vertically upwards and divided into three branches, in the form of a cross.

An abnormal arrangement of three branches springing from a normally-arranged arch has been observed, in which the two carotids have arisen by a common trunk, and the two subclavians separately—the right subclavian, in most instances, being transferred beyond the other branches to the left end of the arch.

III. *Peculiarities in which one or more Secondary Branches, usually given from the Subclavian, are derived directly from the Aorta.*

In nearly all instances belonging to this section, there is only one secondary branch taking origin from the aorta; and the occurrence may either accompany the ordinary arrangement of the primary branches, or co-exist with a diminution, or with an increase in their number. The additional branch, when it is a normal artery transposed, is almost invariably the left vertebral, which in nearly all those cases arises between the left carotid and left subclavian arteries; but it has also been observed to proceed from the aorta beyond the last-named trunk. Very rarely the additional branch is the right vertebral.

The *thyroidea ima*, a small supernumerary artery occasionally found ascending to the thyroid body, sometimes arises from the arch of the aorta.

Development of variations in the aortic arch and its branches.—Many of the most frequent variations in the arrangement of the arch of the aorta and its branches may be explained on referring to the development of those vessels, by supposing that one of the usual branches has become obstructed in early fœtal life, and that the circulation has been carried on by the persistence of one of the original vessels which otherwise would have been obliterated.

Thus in the case of *double aortic arch*, both the fourth branchial vascular arches

remain pervious: in a case of *right aortic arch*, the fourth arch of the right side, instead of that of the left, has remained pervious and has taken on permanent development, while at the same time adjusting deviations from the usual process of development have occurred in parts of the other arches, which lead to a left innominate being the first great vessel rising from the arch, and to the right carotid and right subclavian arteries rising later in succession. Thus, too, transference of the right subclavian artery from its usual connection with the innominate of a natural left aortic arch to the fourth place of origin, and its remarkable passage behind the trachea and gullet, may probably proceed from the obstruction of the part of the fourth right arch which unites the aortic bulb with the aortic root, and is accompanied by persistence of the aortic root itself extending from the main aorta below upwards

Fig. 252.

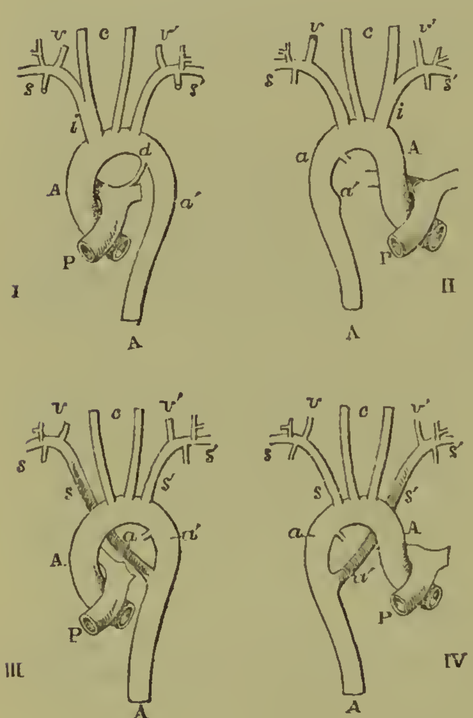


Fig. 252.—Diagrams to illustrate the relation of some abnormal dispositions of the Aortic Arch and its Branches to the Normal Condition.

(I) The normal disposition as illustrated by Fig. 245, p. 326; (II), an abnormal right aortic arch; (III), a left aortic arch with the right subclavian artery displaced to the right aortic root; (IV), an abnormal right aortic arch with the left subclavian displaced to the left aortic root. Upper A, ascending part of the aortic arch; lower A, descending thoracic aorta; P, pulmonary trunk; *d*, ductus arteriosus; *a*, right aortic root or its remains; *a'*, left aortic root; *c*, common carotid arteries; *i*, innominate artery; *s*, right, and *s'*, left subclavian arteries; *v*, right, and *v'*, left vertebral arteries.

to the subclavian artery. The similar transference of a left subclavian artery, in combination with the anomaly of a right aortic arch, may be due to similar abnormal states of development occurring on a different side. So, also, many of the other less marked variations in the number and position of the permanent branches proceeding from the aortic arch probably owe their origin to cognate departures from the usual process of change in those parts of the original vascular arches with which their roots are connected.

By reference to development we are likewise enabled to understand how the right aortic arch of the bird, and the double aortic arch of reptiles, arise by obliteration or permanence of different members of a series of branchial arches comparable with those of fishes.

(Full reference to the history of cases of aortic varieties is given by Turner, "On Varieties of the Arch of the Aorta," Brit. & For. Med. Chir. Review, 1863; and an account of the origin of the varieties as explained by the observation of the development of the vessels is given in the same paper, and in that of A. Thomson, "Description of a Case of Right Aortic Arch," &c., Glasgow Med. Journ. 1862.)

BRANCHES OF THE ARCH OF THE AORTA.

THE CORONARY ARTERIES.

The coronary or *cardiac* arteries are two small vessels, named right and left, which arise from the root of the aorta in the upper parts of the two

anterior of the three sinuses of Valsalva, on a level with the margins of the semilunar valves.

The *right coronary artery*, about the size of a crow's quill, runs obliquely towards the right side of the heart, lodged in the groove which separates the auricle from the ventricle. It continues its course in the same groove, along the posterior aspect of the organ, until it reaches the line of separation between the two ventricles, where it divides into two branches. The smaller

Fig. 253.

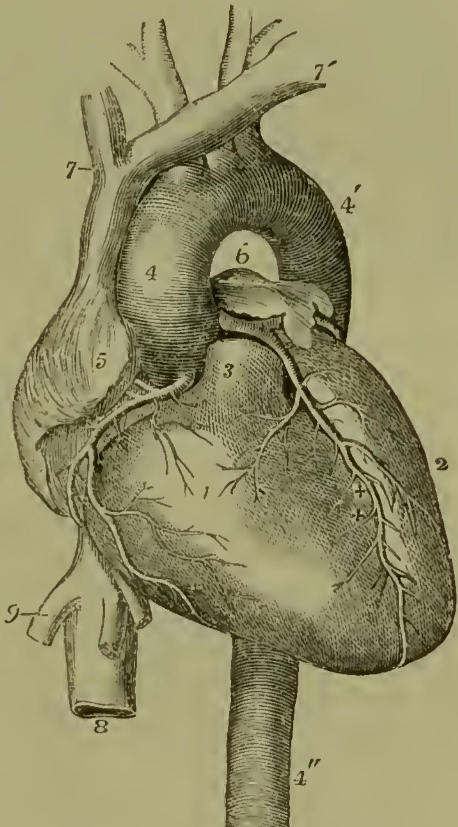


Fig. 253.—View of the Heart and Coronary Arteries from before (from R. Quain). ½

The pulmonary artery has been cut short close to its origin in order to show the first part of the aorta. 1, anterior part of the right ventricle; 2, left ventricle; 3, root of the pulmonary artery; 4, ascending part of the arch of the aorta; 4′, the posterior or descending part of the arch; between these is seen the transverse or middle part from which the brachio-cephalic arteries take their origin; 4″, the descending thoracic aorta; 5, the appendix and anterior part of the right auricle; 6, those of the left auricle; 7, the right, and 7′, the left innominate or brachio-cephalic veins joining to form the vena cava superior; 8, the inferior vena cava below the diaphragm; 9, one of the large hepatic veins; +, placed in the right auriculo-ventricular groove, points to the right or posterior coronary artery; + +, placed in the anterior inter-ventricular groove, points to the left or anterior coronary artery.

of these continues transversely in the groove between the left auricle and ventricle, approaching the termination of the transverse branch of the left coronary artery; while the other branch runs longitudinally downwards along the posterior wall of the septum between the ventricles, giving branches to each ventricle and to the septum between them.

In its course the right coronary artery gives, besides the offsets already noticed, small branches to the right auricle and ventricle, and also to the first part of the pulmonary artery. Along the right border of the ventricle a rather large branch usually descends towards the apex of the heart, and gives offsets, in its progress, to the anterior and posterior surfaces of the ventricle.

The *left coronary artery* is rather smaller than the preceding, and arises from the left anterior sinus of Valsalva. It passes behind and then to the left side of the pulmonary artery, appearing between that vessel and the left auricular appendage. At first it descends obliquely towards the anterior interventricular sulcus, where it divides into two branches. Of these, one pursues a transverse direction, turning outwards and to the left side in the groove between the left ventricle and auricle, and approaching at the posterior aspect of the heart the transverse branch of the right coronary artery; the other branch, much the larger, descends on the anterior

surface of the heart along the line of the interventricular groove, to the right of the apex.

The left coronary artery supplies some small branches at its commencement to the pulmonary artery, to the coats of the aorta, and to the left auricular appendage ; its two branches also furnish throughout their course smaller offsets, which supply the left auricle, both ventricles, and the interventricular septum.

It has been customary to describe the transverse branches of the coronary arteries as anastomosing in the left auriculo-ventricular sulcus, and the descending branches as anastomosing near the apex of the heart, and this description was never doubted till it was found by Hyrtl, as the result of separate injection of these vessels, that the branches of one coronary artery cannot be injected with material introduced into the other. (Nat. Hist. Review, 1861, p. 321.)

Peculiarities.—The *coronary* arteries have been observed in a few instances to commence by a common trunk, from which they diverged and proceeded to their usual destination. The existence of three coronary arteries is not a very rare occurrence, the third being small, and arising close by one of the others. Meckel, in one instance, observed four, the supplementary vessels appearing like branches of one of the coronary arteries transferred to the aorta.

THE INNOMINATE ARTERY.

The innominate, or *brachio-cephalic*, artery, the largest of the vessels which proceed from the arch of the aorta, arises from the commencement of the transverse portion of the arch, before the left carotid artery. From this point the vessel ascends obliquely towards the right, until it arrives opposite the sterno-clavicular articulation of that side, nearly on a level with the upper margin of the clavicle, where it divides into the right subclavian and the right carotid artery. The place of bifurcation would, in most cases, be reached by a probe passed backwards through the cellular interval between the sternal and clavicular portions of the sterno-mastoid muscle. The length of the innominate artery is very variable, but usually ranges from an inch and a-half to two inches.

This artery, lying for the most part within the thorax, is placed behind the first bone of the sternum, from which it is separated by the sterno-hyoid and sterno-thyroid muscles, and a little lower down by the left innominate vein, which crosses the artery at its root. The lower part of the innominate artery lies in front of the trachea, which it crosses obliquely : on its left side is the left carotid artery, with the thymus gland or its remains ; and to the right is the corresponding innominate vein and the pleura.

No branches usually arise from this vessel.

Peculiarities.—The length of the innominate artery sometimes exceeds two inches, and occasionally it measures only one inch or less. Its place of division is a point of surgical interest, inasmuch as upon it in a great measure depends the accessibility of the innominate in the neck, and the length of the right subclavian artery. It has sometimes been found dividing at a considerable distance above the clavicle, and sometimes, but less frequently, below it. Though usually destitute of branches, this vessel has been observed to supply a thyroid branch, the thyroidea ima, and sometimes a thymic branch, or a bronchial, which descends in front of the trachea.

The *thyroidea ima* is an occasional artery. When present, it usually arises (as already stated) from the innominate trunk, but in rare instances it has been observed to come from the right common carotid artery, or from the aorta itself. It is of very different size, in different bodies, and compensates in various degrees for deficiencies

or absence of the other thyroid arteries. It ascends to its destination in front of the trachea, and its presence might therefore complicate the operation of tracheotomy.

COMMON CAROTID ARTERIES.

The common or primitive carotid arteries of the right and left sides of the body are nearly similar in their course and position whilst they are in the neck; but they differ materially in their place of origin, and consequently in their length and position, at their commencement. On the right side the carotid artery commences at the root of the neck behind the upper part of the sterno-clavicular articulation, at the bifurcation of the innominate artery; but on the left side the carotid arises within the thorax, from the highest part of the arch of the aorta, very near the origin of the innominate artery. The left carotid is therefore longer than the right, and it is at first placed at some depth within the thorax.

In consequence of this difference, it is convenient to describe, at first, the thoracic portion of the left carotid, or that part which intervenes between the arch of the aorta and the sterno-clavicular articulation,—after which the same description will suffice for both vessels.

Within the thorax, the left carotid ascends obliquely behind and at some distance from the upper piece of the sternum and the muscles (sterno-hyoid and sterno-thyroid) connected with that part of the bone; it is covered in front by the remains of the thymus gland, and is crossed by the left innominate vein. This part of the artery lies in front of the trachea, and of the œsophagus, which, at the root of the neck, deviates a little to the left side; the thoracic duct is also behind it. The left carotid artery here lies between the innominate and the left subclavian arteries, and the vagus nerve is to its outer side.

In the neck the common carotid artery of either side reaches from behind the sterno-clavicular articulation to the level of the upper border of the thyroid cartilage, where it divides into two great branches, of which one is distributed to the cranium and face, and the other to the brain and eye. These divisions have, from their destination, been named respectively the *external* and *internal carotid arteries.*

The oblique course taken by the common carotid artery along the side of the neck is indicated by a line drawn from the sterno-clavicular articulation to a point midway between the angle of the jaw and the mastoid process of the temporal bone. At the root of the neck, the arteries of opposite sides are separated from each other only by a narrow interval, corresponding with the width of the trachea; but, as they ascend, they are separated by a much larger interval, corresponding with the breadth of the pharynx and larynx. The carotid arteries have the appearance of being placed farther back at the upper than at the lower part of the neck, owing to the forward projection of the larynx above.

The common carotid artery is enclosed, together with the internal jugular vein and the vagus nerve, in a common membranous investment, continuous with the deep cervical fascia. Separated by means of this sheath from all the surrounding parts, except the vein and nerve just mentioned, the carotid artery is deeply placed at the lower part of the neck, but is comparatively superficial towards its upper end. It is covered below by the sterno-mastoid, sterno-hyoid, and sterno-thyroid muscles, in addition to the platysma and the layers of fascia between and beneath the muscles; and it is crossed opposite or near the lower margin of the cricoid cartilage by

the omo-hyoid muscle. From this point upwards to its bifurcation, the vessel is covered by the sterno-mastoid, by the platysma and fascia, and by the common integument; and lies in a triangular space bounded by the sterno-mastoid, the omo-hyoid, and the digastric muscles.

Fig 254.

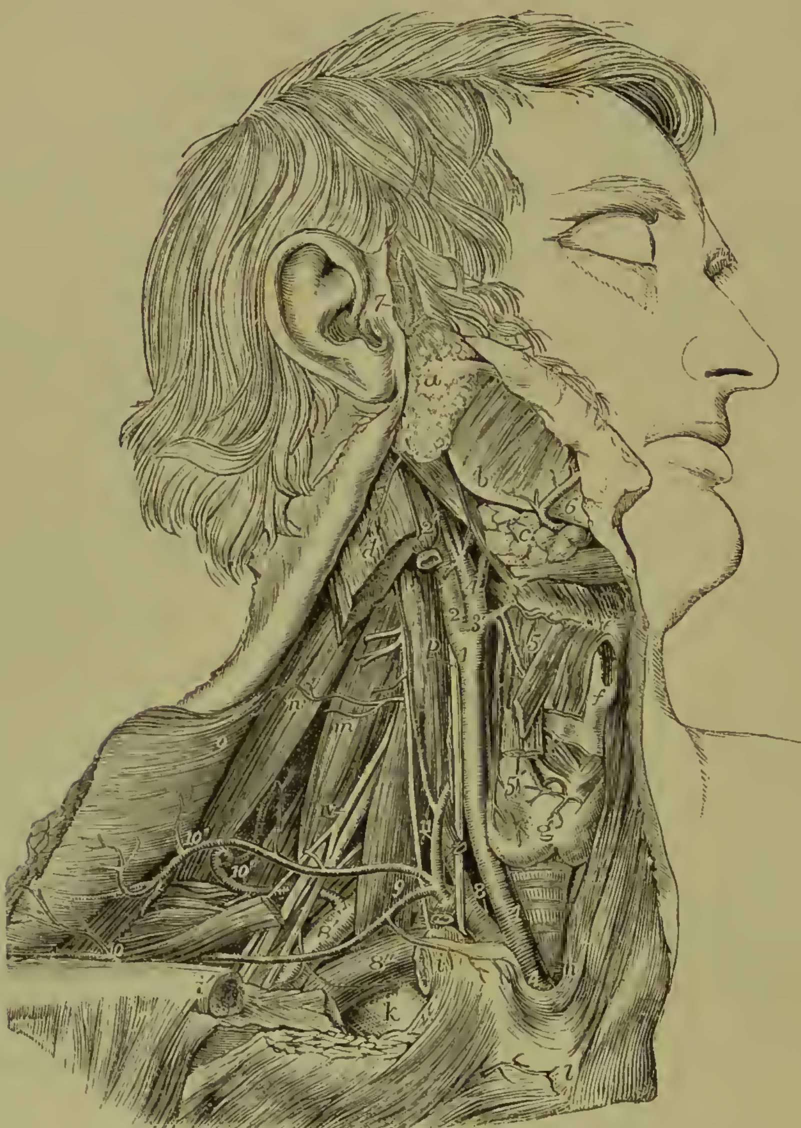


Fig. 254.—View of the Right Common Carotid and Subclavian Arteries, with the Origin of their Branches and their Relations (from R. Quain). ⅓

The sterno-mastoid, sterno-thyroid, sterno-hyoid, and omo-hyoid muscles have been removed, the trapezius has been detached from the outer part of the clavicle and turned backwards, and the inner part of the clavicle has been removed: *a*, parotid gland near the place where the duct of Stenson leaves it: *b*, angle of the jaw and masseter muscle; *c*, submaxillary gland, enclosed between the digastric and stylo-hyoid muscles; *d*, divided upper part of the sterno-mastoid muscle; *e*, front of the hyoid bone; *f*, thyroid cartilage; *g*, isthmus of the thyroid gland; *h*, the trachea above the inter-clavicular notch of the sternum; *i*, *i'*, the sawn ends of the clavicle, the portion between them having been removed; *k*, the first rib, below which is seen the divided edge of the great pectoral muscle, and beside it the subclavius; *l*, front of the sternum; *m*, scalenus medius; *n*, levator anguli scapulæ; *o*, deep surface of the trapezius, which is turned aside; *p*, on the

longus colli muscle, pointing to the pneumogastric nerve; IV, the uppermost of the nerves of the axillary plexus; A, the innominate artery; 1, right common carotid artery; 1′. placed on the left sterno-thyroid muscle, points to a part of the left common carotid; 2, internal carotid; 2′, upper part of the internal jugular vein, which has been removed between *i*, and 2′; 3, and 4, external carotid; 3, is placed at the origin of the superior thyroid artery; 4, at that of the lingual: farther up the vessel may be seen the separation of the sterno-mastoid twig and the facial and occipital branches from the main vessel; 5, is placed on the thyro-hyoid muscle between the hyoid and laryngeal branches of the superior thyroid artery; 5′, the thyroid or glandular; 6, the facial artery passing over the base of the jaw; 7, the superficial temporal artery; 8, the first part, 8′, the third part of the arch of the subclavian artery; 8″, the subclavian vein separated from the artery by the scalenus anticus muscle, shown by the removal of a portion of the clavicle; 9, is placed on the scalenus anticus muscle in the angle between the transversalis colli and supra-scapular branches of the thyroid axis; 10, outer part of the supra-scapular artery; 10′, transverse cervical branches passing into the deep surface of the trapezius; 10″, the posterior scapular artery, represented as rising directly from the third part of the subclavian artery, and passing through the axillary plexus of nerves and under the levator anguli scapulæ; 11, on the scalenus anticus muscle, points to the inferior thyroid artery near the place where the ascending muscular artery of the neck is given off; the phrenic nerve lies on the muscle to the outside; at *i*, the supra-sternal twig of the supra-scapular artery is shown.

Posteriorly, the artery is supported by the cervical vertebræ, the longus colli and rectus capitis anticus muscles intervening. Hence the flow of blood through it may be commanded by pressure directed backwards against the vertebral column. The inferior thyroid artery crosses behind the carotid sheath.

On the inner side the vessel is in juxtaposition with the trachea below, and with the thyroid body (which often overlaps the artery), the larynx, and the pharynx higher up. Along its outer side are placed the internal jugular vein and the vagus nerve.

Relation to Veins.—The *internal jugular* vein is close to the artery at the upper part of the neck, but in approaching the thorax, the veins of both sides incline to the right, and hence that of the right side is separated from the artery by an angular interval, while that of the left side approaches the artery, and even lies in front of it at the lower part of the neck.

Crossing over the upper part of the common carotid artery to join with the jugular vein, are two or more *superior thyroid veins*, which occasionally form a sort of plexus over the artery. A *middle thyroid vein* not unfrequently crosses the artery about half way up the neck.

The *anterior jugular vein*, where it turns outwards under the sterno-mastoid muscle to join the subclavian, crosses the lower part of the artery. This vein is generally of small size, but occasionally is rather large, and is placed nearly over the carotid artery along the neck.

Relation to Nerves.—The descending branch of the hypo-glossal nerve, *descendens noni*, usually rests, together with the branches of cervical nerves which join it, on the fore part of the sheath of the carotid artery, and crosses it from the outer to the inner side: in some instances this branch descends within the sheath between the carotid artery and jugular vein. The *vagus nerve* lies within the sheath of the vessels between the artery and vein posteriorly: it was in one case observed to descend over the artery. The *sympathetic nerve* is placed along the back of the sheath, between it and the vertebral muscles, and the *recurrent laryngeal nerve* crosses inwards behind the upper part of the sheath.

The common carotid artery usually gives off no branch, and therefore continues of equal size in its whole length, except at its bifurcation, where a slight enlargement is observable.

Fig. 255.

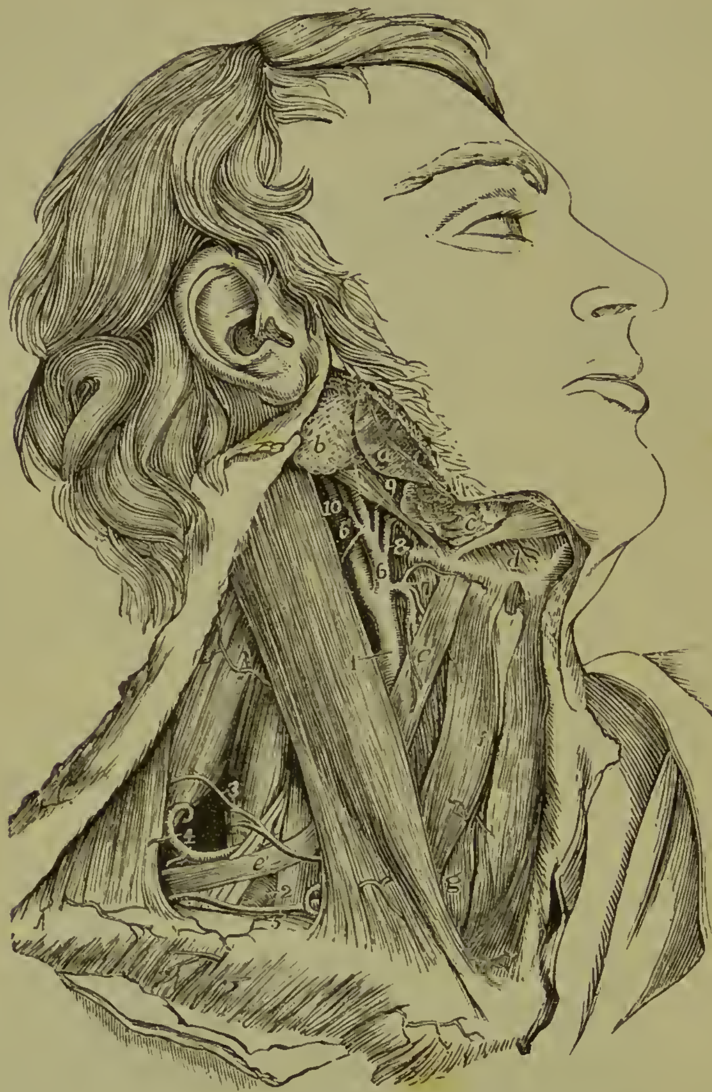


Fig. 255.—Dissection of the Right Side of the Neck to show the Muscular Triangles, the Carotid and Subclavian Arteries, &c. (from R. Quain). $\frac{1}{3}$

a, angle of the jaw and masseter muscle; *b*, parotid gland; +, the posterior belly of the digastric muscle; *c*, submaxillary gland; *d*, upon the mylohyoid muscle below the anterior belly of the digastric muscle, and above the front of the hyoid bone; *e*, upper belly of the omohyoid muscle; *e'*, lower belly; *f*, sterno-hyoid muscle; *g*, sterno-thyroid; 1, upon the sterno-mastoid muscle, points by a line to the upper part of the common carotid artery; 2, upon the scalenus anticus muscle, points to the third part of subclavian artery; 3, upon the scalenus medius, points to the superficial transverse cervical artery crossing the axillary nerves; 4, points to the posterior scapular artery, passing under the levator scapulæ muscle; 5, placed upon the clavicle, points to the supra-scapular artery; 6, external carotid artery; 6', internal carotid artery; 7, upon the thyro-hyoid muscle, points to the superior thyroid artery giving superiorly its hyoid branch; 8, is placed upon the hyo-glossus muscle within the arch of the lingual artery; 9, placed on the stylo-hyoid muscle, indicates the facial artery; 10, origin of the occipital artery, from the root of which the small sterno-mastoid artery is given off; between the occipital and the facial arteries, +, upon the posterior belly of the digastric muscle, points to the continuation of the external carotid artery before entering the parotid gland.

The absence of branches from the trunk of the common carotid is connected with

the original absence of the neck in the fœtus, and the comparatively late period at which, when the neck is formed, the carotid artery becomes elongated with it.

PECULIARITIES.—*Origin.*—The *right carotid* artery occasionally arises directly from the aorta, or in conjunction with the left carotid. When it arises from the aorta, it is usually the first vessel from the arch, the subclavian being displaced; but it has been found to occupy the second place,—the right subclavian, or, very rarely, the left carotid being the first.

The place at which the right carotid artery commences, varies with the point of bifurcation of the innominate artery. A change from the usual position on a level with the upper border of the clavicle was found by R. Quain in the proportion of about one case in eight and a half of those observed by him; and it was found to occur more frequently above than below that point.

The *left carotid* artery varies in its *origin* much more frequently than the right. In the greater number of its deviations from the ordinary place of origin, this artery arises from, or in conjunction with the innominate artery; and in those cases in which the right subclavian is a separate branch of the aorta, the two carotids most frequently arise by a common trunk.

In cases of transposition, or of right aortic arch without other abnormality, the left common carotid springs from a left innominate artery, which is the first vessel to rise from the arch, and the right carotid is the second vessel.

Place of division.—This often deviates somewhat from its usual position; it does so more frequently in an upward than in a downward direction. It is often as high as the os hyoides, and occasionally much higher. It is found from time to time opposite the middle of the larynx, and, in rare instances, opposite the lower margin of the cricoid cartilage, or even lower.

One case was observed by Morgagni, in which the carotid artery, measuring one inch and a half in length, divided at the root of the neck. ("De Sedibus et Causis Morborum," &c. Epist. 29, Art. 20.)

The common carotid artery has been found, as a very rare occurrence, to ascend in the neck *without dividing* into its two usual terminal branches; the internal carotid artery being altogether wanting.

In two recorded cases the common carotid artery was absent; the external and internal carotids arising directly from the arch of the aorta.

Occasional branches.—The common carotid artery sometimes gives origin at its upper part to the superior thyroid artery, and, in some rare cases, to a laryngeal or an inferior thyroid branch; also, in a few instances, to the vertebral artery.

EXTERNAL CAROTID ARTERY.

The external carotid artery, distributed mainly to the face and to the walls of the cranium, is smaller than the internal carotid in young persons; but the two are nearly of equal size in adults. It reaches from the point of division of the common carotid, opposite the upper margin of the thyroid cartilage, to the neck of the condyle of the lower jaw-bone, or a little lower, and there divides into its two terminal branches, the temporal and the internal maxillary. It diminishes rapidly as it ascends, owing to the number and size of the branches which spring from it.

At first the external carotid lies nearer to the middle line of the body than the internal carotid; but it soon becomes superficial to that artery, at the same time curving slightly forwards as it ascends to its place of division. At its origin this artery is concealed by the sterno-mastoid muscle, emerging from beneath which, it is covered only by the platysma myoides and the fascia, and traverses the upper part of a triangular intermuscular space bounded by the sterno-mastoid, omo-hyoid and digastric muscles; it then becomes deeply placed, passing beneath the stylo-hyoid and digastric muscles, and finally becoming imbedded in the substance of the parotid gland. In the lower part of its course it is in contact with the pharynx

and hyoid bone; further up it is separated by a portion of the parotid gland from the back of the ramus of the lower jaw, and rests upon the styloid process and the stylo-pharyngeus muscle, which, with the glosso-pharyngeal nerve, are interposed between it and the internal carotid artery.

Relation to Veins.—This artery has usually no companion vein, though it may be crossed superficially by small branches of the contiguous veins; but when the internal maxillary vein joins the deep instead of the superficial jugular, it accompanies the external carotid.

Relation to Nerves.—Close to the digastric muscle the external carotid artery is crossed by the *hypoglossal nerve*, and at a short distance from its upper end, in the substance of the parotid gland, by the *facial nerve*. The *glosso-pharyngeal nerve* lies between it and the internal carotid; and the *superior laryngeal nerve* is under both vessels.

Branches.—The branches of the external carotid artery are eight in number, viz. three directed forwards, the superior thyroid, the lingual, and the facial; two directed backwards, the occipital, and posterior auricular; and three extending upwards, the ascending pharyngeal branch, together with the temporal and internal maxillary, the two terminal branches into which the artery divides.

In addition to the principal branches here enumerated, the external carotid gives off small offsets to the parotid gland.

Peculiarities.—The peculiarities in the origin of this vessel have been noticed along with those of the common carotid artery.

The branches are not unfrequently crowded together on the main stem, near the commencement, or at a higher point. Occasionally they take origin at regular distances in the whole length of the vessel.

The usual number of branches may be diminished by the association with another artery of one of the ordinary branches, or by the union into a single trunk of two or three branches which are usually derived separately from the main artery: so also the number may be augmented by the transfer to this vessel of some branch not ordinarily derived from it, or by the addition of some unusual branch.

There is frequently present a small distinct branch for the sterno-mastoid muscle, which bends outwards over the hypoglossal nerve.

BRANCHES OF THE EXTERNAL CAROTID ARTERY.

I. SUPERIOR THYROID ARTERY.

The superior thyroid artery, the first of the anterior set of branches, is given off close to the commencement of the external carotid, immediately below the great cornu of the hyoid bone. From this point the artery curves forwards and downwards to the upper margin of the thyroid cartilage; it then descends a short distance beneath the omo-hyoid, sterno-hyoid and sterno-thyroid muscles, furnishing offsets to those muscles; and, reaching the anterior surface of the thyroid body, distributes branches to its substance, and communicates freely with the branches of the inferior thyroid artery.

Branches.—

Besides the branches furnished to the muscles which cover it, and to the thyroid body, together with some to the lowest constrictor of the pharynx, the superior thyroid furnishes the following offsets, which have received distinctive names:—

(*a*) The *hyoid*, a small branch, running transversely inwards immediately below

Fig. 256.

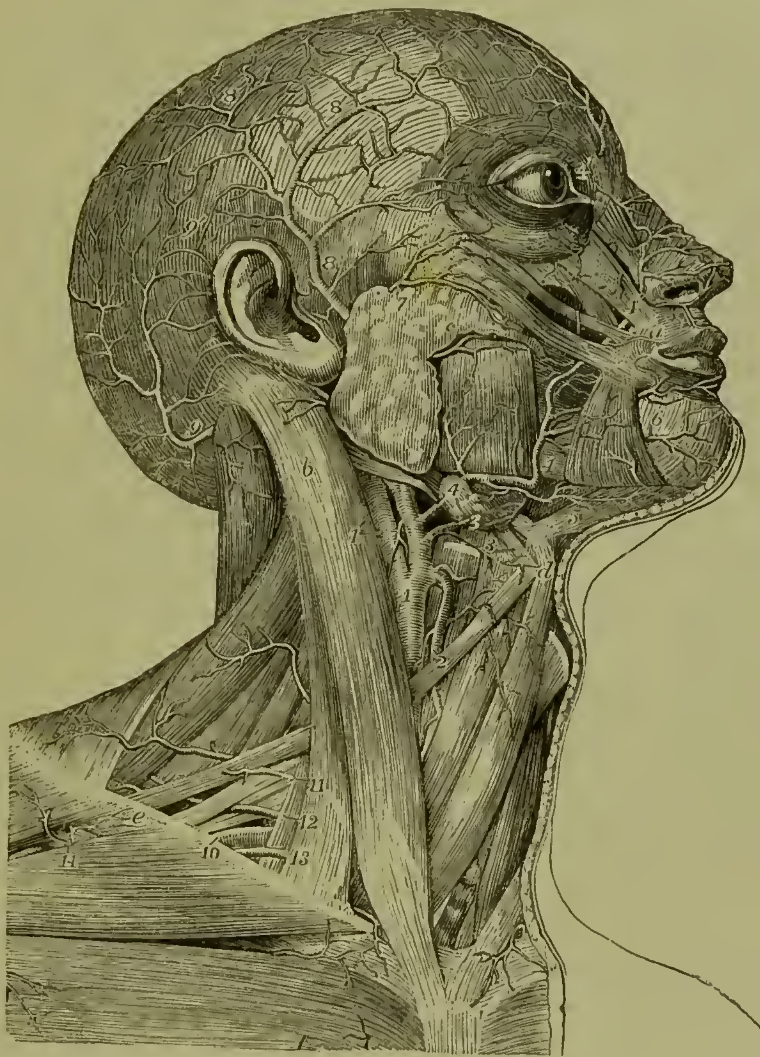


Fig. 256.—SUPERFICIAL VIEW OF THE ARTERIES OF THE HEAD AND NECK (from Tiedemann). $\frac{1}{3}$

a, placed upon the orbicularis oris near the place where it is joined by the levator labii superioris, the zygomaticus minor and major and triangularis oris; *b*, upper part of the sterno-mastoid muscle; *c*, parotid gland near its duct; *d*, body of the hyoid bone near the place of meeting of the digastric, stylo-hyoid, sterno-hyoid and omo-hyoid muscles; *e*, is placed on the clavicle at the place where, superiorly, the omo-hyoid dips behind it and the trapezius muscle, and inferiorly the interval exists between the pectoral and deltoid muscles; 1, trunk of the common carotid artery near its division into the external and internal carotid arteries; 1′, the internal carotid; 2, placed on the upper belly of the omo-hyoid muscle, points to the superior thyroid artery; 3, lingual artery and its hyoid branch; 4, placed on the submaxillary gland at the place where the facial artery is sunk in the gland, and again where the artery turns over the lower jaw; 4′, termination of the facial artery by division into the angular and lateral nasal branches; 5, sub-mental branch; 6, inferior labial branches; 7, transverse facial branch of the superficial temporal; 8, superficial temporal, passing over the zygoma and distributed by 8′ 8′, its anterior and posterior divisions on the surface of the cranium; 9, occipital artery rising upon the cranium; 9′, its distribution and anastomosis with the temporal and posterior auricular arteries; 10, outer part of the subclavian artery; 11, superficial cervical, and 12, posterior scapular arteries; 13, supra-scapular artery; 14, acromio-thoracic branches of the axillary artery.

the os hyoides, and assisting to supply the soft parts connected with that bone. This little artery sometimes unites, across the middle line, with its fellow from the opposite side.

(*b*) A *superficial descending* branch, which passes downwards a short distance over the sheath of the large cervical vessels, and ramifies in the sterno-mastoid and the muscles attached to the thyroid cartilage, as well as in the platysma and neighbouring integuments. The position of this branch with respect to the sheath of the carotid artery is the only circumstance which gives it interest.

(*c*) The *laryngeal* branch, or *superior laryngeal artery*, proceeding inwards in company with the superior laryngeal nerve, and piercing the thyro-hyoid membrane. Before entering the larynx this branch is covered by the thyro-hyoid muscle. On reaching the interior of the larynx, it ramifies in the small muscles, the glands, and the mucous membrane of that organ.

(*d*) The *crico-thyroid*, a small branch, to be noticed on account of its position rather than its size. It crosses the membrane connecting the thyroid and cricoid cartilages, and communicates with a similar branch from the other side: hence it may be a source of hæmorrhage in the operation of laryngotomy.

Peculiarities.—*Size.*—The superior thyroid artery is frequently much larger, and, on the other hand, it may be smaller than usual. In either case the deviation from the accustomed size is accompanied by an opposite alteration in other thyroid arteries. It has been seen extremely small, ending in branches to the sterno-mastoid muscle and the larynx. (See the observations on the inferior thyroid artery.)

Origin.—The superior thyroid is often transferred to the upper part of the common carotid artery; and it has been seen conjoined with the lingual branch, or with that and the facial branch of the external carotid.

There are sometimes two superior thyroid arteries.

Branches.—The *hyoid* branch is frequently very small, or absent. The *laryngeal* branch arises not unfrequently from the external carotid artery, and likewise, but rarely, from the common carotid. Examples have occurred of this branch being of very large size, and terminating in the thyroid body. The laryngeal artery occasionally enters the larynx through a foramen in the thyroid cartilage; and it has likewise been observed to pass inwards below the cartilage.

II. LINGUAL ARTERY.

The *lingual artery* arises from the inner side of the external carotid, between the origins of the superior thyroid and facial arteries. Curving upwards and inwards, it reaches the upper margin of the hyoid bone, behind the tip of its great cornu; it then passes forwards under cover of the hyo-glossus muscle, resting at first on the middle constrictor of the pharynx, and afterwards on the genio-hyo-glossus muscle, in contact with which it ascends almost perpendicularly to reach the under surface of the tongue, and there makes its final turn forwards to the tip of that organ, receiving the name of ranine artery.

At the posterior border of the hyo-glossus muscle, the *hypoglossal* nerve crosses the artery, and passes forwards on a lower level, superficial to the muscle.

Branches.—The branches of the lingual artery are as follows:—

(*a*) The *hyoid* branch, running along the upper border of the hyoid bone, and supplying the contiguous muscles and skin.

(*b*) The *dorsal artery of the tongue*, which is often replaced by several smaller branches. It arises from the deep portion of the lingual artery, beneath the hyo-glossus muscle, and ascends to supply the upper part, or dorsum, and the substance of the tongue, ramifying as far back as the epiglottis.

(*c*) The *sublingual* branch. Taking origin at the anterior margin of the hyo-glossus, this branch turns slightly outwards, under cover of the mylo-hyoid muscle, and between this and the sublingual gland. It supplies the substance of the gland, and gives branches to the mylo-hyoid and other muscles connected with the maxillary

bone. Small branches are also distributed to the mucous membrane of the mouth, and the inside of the gums.

(*d*) The *ranine* artery, which may be considered from its size and direction the continuation of the lingual artery. It runs forwards beneath the tongue, giving numerous branches as it proceeds, covered by the mucous membrane, and resting on the genio-hyo-glossus muscle. Having reached the tip of the tongue, it has been said to anastomose with the corresponding artery of the other side; but this is denied by Hyrtl. In the last part of its course it lies quite superficially at the side of the frænum.

Peculiarities.—The origin of the lingual artery sometimes takes place from a trunk common to it and the facial artery. It is occasionally joined with the superior thyroid.

Branches.—The *hyoid* branch is often deficient; and it appears that this branch varies in size inversely with the hyoid branch of the superior thyroid.

The *sublingual* branch varies in size. It is sometimes derived from the facial artery, and then perforates the mylo-hyoid muscle.

The lingual artery has been seen to give off as *unusual* branches, the submental and ascending palatine.

III. FACIAL ARTERY.

The facial artery (art. maxillaris externa), taking origin a little above the lingual artery, is first directed obliquely forwards and upwards beneath the base of the maxillary bone; then changing its direction, it passes upwards over the base of the lower maxilla, in front of the masseter muscle. Commencing here its course upon the face, it is directed forwards near to the angle of the mouth, and ascends to the inner canthus of the eye, where it ends by anastomosing with the ophthalmic artery. In its whole course the artery is tortuous, a circumstance connected with the great mobility of the parts on which it rests.

In the neck, the facial artery, immediately after its origin, which is comparatively superficial, being covered only by the platysma and fascia, is crossed by the digastric and stylo-hyoid muscles, and is then concealed in the substance of the submaxillary gland. Emerging from the gland, it turns over the border of the jaw, covered by the platysma: here the pulsation of the artery is easily felt, and the circulation through it may be readily controlled by pressure against the bone. In its progress over the face, it is covered successively by the platysma and the zygomatic muscles, and rests upon the buccinator, the levator anguli oris, and the levator labii superioris.

The *facial vein* is separated by a considerable interval from the artery on the face. It takes nearly a straight course upwards, instead of inclining forwards near the angle of the mouth, and it is not so tortuous as the artery.

Branches of the *portio dura nerve* cross the vessel; and the *infra-orbital nerve* is beneath it, separated by the fibres of the elevator of the upper lip.

Branches.—A. *Cervical branches.*—The following branches are derived from the facial artery below the lower jaw :—

(*a*) The *inferior* or *ascending palatine artery*, a branch which ascends between the stylo-glossus and stylo-pharyngeus muscles, and reaches the pharynx close to the border of the internal pterygoid muscle. After having given small branches to the tonsil, the styloid muscles, and the Eustachian tube, this artery divides near the levator palati muscle into two branches, one of which follows the course of the circumflexus palati muscle, and is distributed to the soft palate and its glands, while the other penetrates to the tonsil, and ramifies upon it with the branch to be next described.—The place of this artery upon the palate is often taken by the ascending pharyngeal.

(*b*) The *tonsillar* branch, which ascends along the side of the pharynx, and penetrating the superior constrictor of the pharynx, terminates in small vessels upon the tonsil and the side of the tongue near its root.

(*c*) The *glandular* branches, a numerous series which enter the substance of the submaxillary gland, whilst the facial artery is in contact with it; and some of which are prolonged upon the side of the tongue.

(*d*) The *submental* branch, the largest arising from the facial in the neck. Leaving the artery near the point at which it turns upwards to the face, it runs forwards below the base of the maxillary bone on the surface of the mylo-hyoid muscle and subjacent to the digastric. Giving branches in its course to the submaxillary gland and the muscles attached to the jaw, it approaches the symphysis of the chin and divides into two branches; one of these, running more superficially than the other, passes between the depressor muscle of the lower lip and the skin, supplying both; while the other dips between that muscle and the bone, and ramifies in the substance of the lip, communicating with the inferior labial branch.

B. *Facial branches.*—Of the branches derived from the facial artery upon the side of the face, some are directed outwards to the muscles, as to the masseter and buccinator, and require only to be indicated. Larger branches described with some detail are directed inwards, and are as follows :—

(*a*) The *inferior labial* branch. This arises soon after the facial artery has turned over the lower border of the maxilla, and running forwards beneath the depressor anguli oris, distributes branches to the skin and the muscles of the lower lip, anastomosing with the inferior coronary and submental branches, and with the inferior dental branch of the internal maxillary artery.

(*b*) The *coronary artery* of the lower lip. Arising near the angle of the mouth, as often in conjunction with the superior coronary as from the facial separately, this branch penetrates the muscular fibres surrounding the orifice of the mouth, takes a transverse and tortuous course between those fibres and the mucous membrane of the lip, and inosculates with the corresponding artery of the opposite side. Small twigs from it ascend to supply the orbicular and depressor muscles, the glands, and other structures of the lower lip; whilst others descend towards the chin, and communicate there with other branches.

(*c*) The *coronary artery* of the upper lip. Larger and more tortuous than the preceding branch, with which it often arises, this vessel runs across between the muscles and mucous membrane of the upper lip, and inosculates with its fellow of the opposite side. In addition to supplying the whole thickness of the upper lip, it gives two or three small branches to the nose. One of these, named the *artery of the septum*, runs along the lower border of the septum nasi, on which it ramifies as far as the point of the nose; another reaches the ala of the nose.

(*d*) The *lateral nasal artery*. This branch turns inwards to the side of the nose beneath the common elevator of the nose and lip, and sends branches to the ala and the dorsum of the nose. It anastomoses with the nasal branch of the ophthalmic, with the artery of the septum nasi, and with the infra-orbital artery.

(*e*) *Angular artery*. Under this name is recognised the terminal part of the facial artery, which inosculates at the inner side of the orbit with a terminal branch of the ophthalmic artery.

Communication between the superficial and deep branches of the external carotid is established by the anastomoses of the facial artery with the infra-orbital, buccal, inferior dental, and nasal branches of the internal maxillary; and between the external and the internal carotids by the anastomosis of the facial with the ophthalmic arteries.

Peculiarities.—*Origin*.—The facial artery not unfrequently arises by a common trunk with the lingual. Occasionally it arises above its usual position, and then descends beneath the angle of the jaw to assume its ordinary course.

Size.—This artery varies much in size, and in the extent to which it is distributed. It has been observed, very rarely however, to end as the submental, not reaching the side of the face; in some cases it supplies the face only as high as the lower lip. The deficiency of the facial artery is most frequently compensated for by an enlarge-

ment of the nasal branches of the ophthalmic at the inner side of the orbit; occasionally by branches from the transverse facial or internal maxillary arteries.

Branches.—The *ascending palatine* artery is in some instances transferred to the external carotid. This branch varies in size and the extent to which it reaches. Not unfrequently it is expended without furnishing any branch to the soft palate. When it is thus reduced in size, the pharyngeal artery takes its place on the soft palate.

The *tonsillar* branch is not unfrequently altogether wanting.

The *submental* branch has been observed to take its rise from the lingual artery. On the other hand, the facial artery, instead of the lingual, has been found to furnish the branch which supplies the sublingual gland.

IV. OCCIPITAL ARTERY.

The occipital artery, arising from the posterior part of the external carotid, usually opposite the facial or a little higher up, is directed upwards and backwards, beneath the posterior belly of the digastric muscle, to the interval between the transverse process of the atlas and the mastoid process of the temporal bone. From that point it turns horizontally backwards along the skull in the occipital groove of the temporal bone, internal to the mastoid process and the sterno-mastoid, splenius, digastric and trachelo-mastoid muscles, and resting on the superior oblique and complexus muscles. Lastly, changing its direction a second time, and piercing the cranial attachment of the trapezius, it ascends beneath the integument on the back of the head accompanied by the great occipital nerve, and divides into numerous branches upon the upper and back part of the cranium. While in the neck, the occipital artery crosses over the internal carotid artery, the vagus and spinal accessory nerves, and the internal jugular vein; and the hypoglossal nerve turns from behind over it at its origin.

Branches.—The following *branches* are given from the occipital artery:—

(*a*) Small *muscular* offsets to the digastric and stylo-hyoid muscles, and one of larger size to the sterno-mastoid. This last is so regular a branch that it is known as the *sterno-mastoid* branch.

(*b*) An *auricular* branch to the back part of the concha of the ear, and two or three other muscular branches to the splenius and trachelo-mastoid.

(*c*) The *meningeal* branch. This runs up with the internal jugular vein, enters the skull through the foramen jugulare, and ramifies in the dura mater of the posterior fossa of the base of the skull.

(*d*) The *cervical* branch, *ramus cervicalis princeps*. To the upper and back part of the neck the occipital artery furnishes a branch thus designated. Descending a short way, this vessel divides into a superficial and a deep branch. The former ramifies beneath the splenius, sending offsets through that muscle to the trapezius; while the deep branch passes beneath the complexus, and anastomoses with branches of the vertebral artery, and with the deep cervical artery. The size of this branch varies very much.

(*e*) The *superficial* or *cranial* branches. These pursue a tortuous course between the integument and the occipito-frontalis muscle; and in proceeding upwards on the skull they separate into diverging branches, which communicate with the branches of the opposite artery, as well as with those of the posterior auricular artery, and of the temporal artery at the vertex and side of the skull.

A small twig, the *mastoid* branch, enters the skull through the mastoid foramen, and ramifies in the dura mater.

Peculiarities.—*Origin.*—The occipital artery is occasionally derived from the internal carotid, and from the ascending cervical branch of the inferior thyroid—an offset of the subclavian artery.

Course.—The occipital artery sometimes passes outside the trachelo-mastoid muscle, instead of internal to it. The chief portion of the vessel was found, in one instance, to pass over the sterno-mastoid muscle, only a small artery being placed in the usual

Fig. 257.

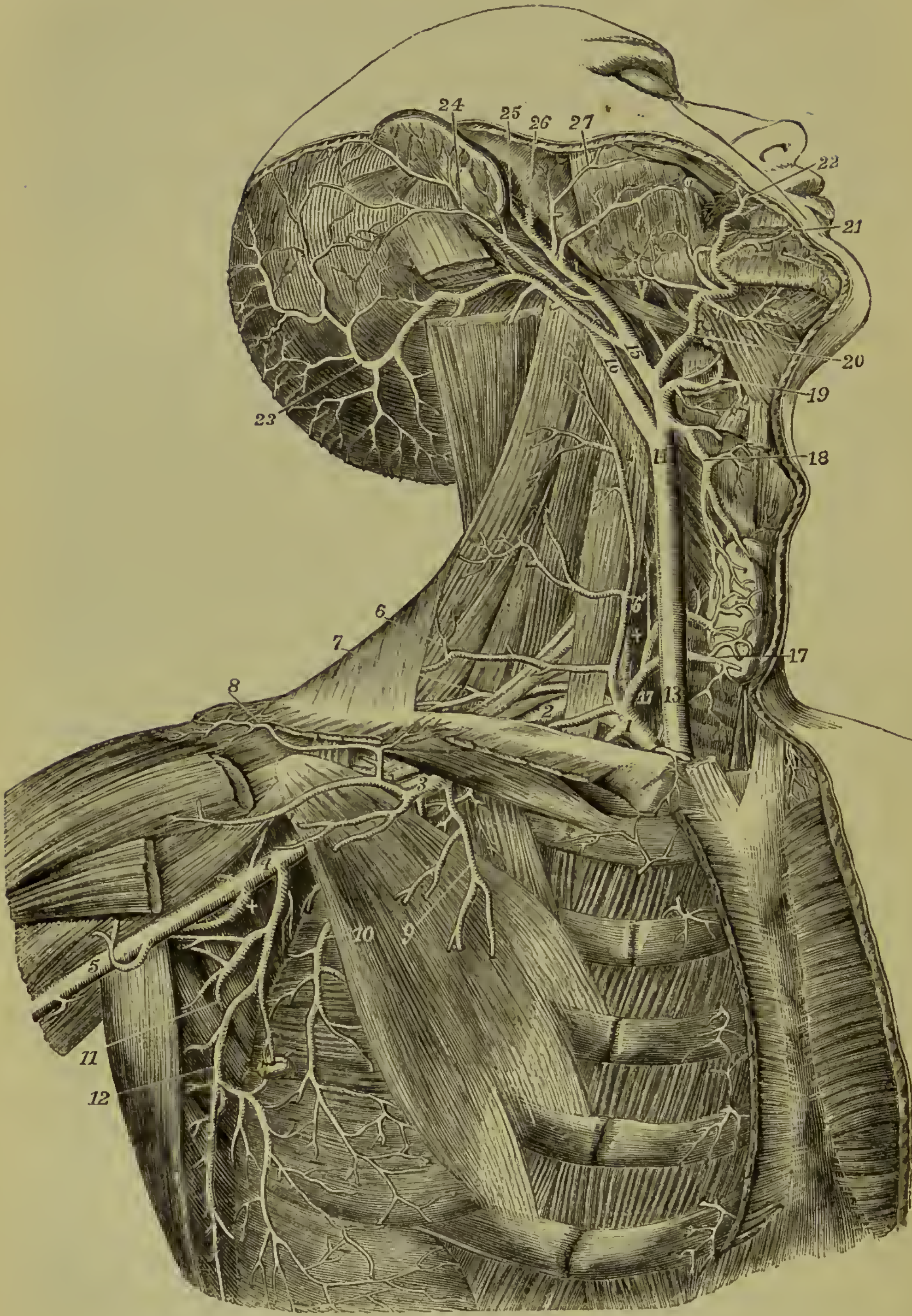


Fig. 257.—Deep View of the Carotid, Subclavian, and Axillary Arteries (from Tiedemann). $\frac{1}{3}$

The great pectoral, the sterno-mastoid, and the sterno-hyoid and sterno-thyroid muscles have been removed; the front part of the deltoid has been divided near the clavicle; the greater part of the digastric muscle has been removed, and the upper part of the splenius capitis and trachelo-mastoid divided near the mastoid process. *Subclavian Artery and its Branches.*—1, first or inner part of the subclavian artery, giving rise to the thyroid axis and internal mammary, and also to +, the vertebral artery; 2, third part of the

subclavian artery outside the scalenus anticus muscle; 3, first part of the axillary artery giving rise to the acromio-thoracic, short thoracic, &c.; 4, third part of the axillary artery, giving rise to the subscapular, circumflex, &c.; 5, commencement of the brachial artery; 6, superficial transverse cervical artery; 6′, placed on the scalenus anticus muscle marks the superficial ascending cervical branch; 7, posterior scapular artery, arising from the subclavian artery behind the scalenus anticus muscle, and separate from the thyroid axis; 8, acromial branches of the acromio-thoracic; 9, pectoral branches of the same; 10, long thoracic artery outside the pectoralis minor muscle; +, posterior circumflex branch of the axillary artery, the anterior circumflex is seen rising from the opposite side of the same part of the axillary trunk; 11, subscapular artery, passing between the subscapularis and teres minor muscles to proceed to the lower angle and dorsum of the scapula; 12, thoracic descending branch of the subscapular artery. *Carotid Artery and its Branches.*—13, lower part, and 14, upper part of the right common carotid artery; 15, trunk of the external carotid artery, brought fully into view by the removal of the digastric muscle; 16, trunk of the internal carotid artery; 17, 17, inside the thyroid axis of the subclavian artery, and on the inferior thyroid artery where it is distributed in the gland; 18, superior thyroid artery, anastomosing in the gland with the inferior thyroid; 19, lingual artery, brought into view by the removal of the lower part of the hyo-glossus muscle; 20, facial artery, giving off the palatine, tonsillitic and submental; 21, inferior labial; 22, coronary artery; 23, occipital artery; 24, posterior auricular artery; 25, superficial temporal artery; 26, internal maxillary artery; 27, transverse facial, given off in this instance directly by the external carotid artery.

position. The artery has, in a few instances, been seen to turn backwards below the transverse process of the atlas.

Branches.—The posterior auricular and the pharyngeal arteries sometimes take origin from the occipital.

V. POSTERIOR AURICULAR ARTERY.

The posterior auricular artery, a small vessel, arises from the external carotid a little higher up than the occipital. It ascends, under cover of the parotid gland, and resting on the styloid process of the temporal bone, reaches the angle formed by the cartilage of the ear with the mastoid process. It is crossed by the portio dura of the seventh nerve. Somewhat above the mastoid portion of the temporal bone it divides into two sets of branches, of which one set inclines forwards to anastomose with the posterior branch of the temporal artery, and the other backwards towards the occiput, on which it communicates with the occipital artery.

Branches.—The following are the branches given off by the posterior auricular artery:—

(*a*) Small branches to the parotid gland and the digastric muscle.

(*b*) The *stylo-mastoid* branch. This twig enters the foramen of the same name in the temporal bone; on reaching the tympanum, it divides into delicate vessels, which pass, some to the mastoid cells, others to the labyrinth. One branch is constantly found in young bodies to form, with the tympanic branch of the internal maxillary artery which enters the fissure of Glasser, a vascular circle around the auditory meatus, from which delicate offsets ramify upon the membrana tympani. This small tympanic branch sometimes arises from the occipital artery.

(*c*) *Auricular branches.*—As it passes the back of the ear, the auricular artery gives one or two branches which supply the posterior surface of the concha, and turn over the margin, or perforate the substance of the auricle to gain the anterior surface.

Peculiarities.—The posterior auricular artery is frequently very small, and has been seen to end in the stylo-mastoid branch. It is often a branch of the occipital.

VI. TEMPORAL ARTERY.

The temporal artery, one of the two branches into which the external carotid artery finally divides a little below the condyle of the lower jaw,

continues upwards in the direction of the parent vessel, whilst the other branch (the internal maxillary) curves forwards under cover of the jaw. The temporal artery is at first imbedded in the substance of the parotid gland, in the interval between the meatus of the ear and the condyle of the lower jaw. Thence it ascends over the root of the zygoma, against which it may readily be compressed. From this point onwards, it lies close beneath the skin, supported by the temporal muscle and fascia; and, about two inches above the zygoma, divides into two branches, which again subdivide and ramify beneath the integument on the side and upper part of the head.

Branches.—Besides several small offsets to the parotid gland, some branches to the articulation of the lower jaw, and one or two to the masseter muscle, the temporal artery gives off the following branches:

(a) The *transverse* artery of the face. This branch arises whilst the temporal artery is deeply seated in the parotid gland, through the substance of which it runs nearly horizontally forwards; getting between the parotid duct and the zygoma, it rests on the masseter muscle, and is accompanied by one or two transverse branches of the facial nerve. It gives small vessels to the parotid gland, the masseter muscle, and the neighbouring integument; and divides into three or four branches, which are distributed to the side of the face, anastomosing with the infra-orbital and facial arteries.

(b) The *middle temporal* branch. This arises close above the zygoma, and immediately perforating the temporal fascia, sends branches to the temporal muscle, which communicate with the deep temporal branches of the internal maxillary artery. An offset from this artery runs to the outer angle of the orbit, where it gives branches to the orbicularis palpebrarum muscle.

(c) The *anterior auricular* branches, two or more in number, superior and inferior. These branches arise above the middle temporal. They are distributed to the fore-part of the pinna, the lobe of the ear, and a part of the external meatus, anastomosing with the ramifications of the posterior auricular artery.

(d) The *anterior temporal* branch, one of the two terminal branches of the temporal artery. This vessel inclines forwards as it ascends over the temporal fascia, and ramifies extensively upon the forehead, supplying the orbicular and occipito-frontal muscles, the pericranium, and the skin, and communicating with the supra-orbital and frontal branches of the ophthalmic artery. On the upper part of the cranium the branches of this artery are directed from before backwards. When it is desired to take blood from the temporal artery, the anterior temporal branch is selected for the operation.

(e) The *posterior temporal branch*. This is usually larger than the anterior, passes back on the side of the head, above the ear, and over the temporal fascia; its branches ramify freely in the coverings of the cranium, both upwards to the vertex, where they communicate with the corresponding vessel of the opposite side, and backwards to join with the occipital and posterior auricular arteries.

Peculiarities.—The *temporal artery* is frequently tortuous, especially in aged persons. Occasionally a large unusual branch runs forward above the zygoma to the upper part of the orbit. The temporal artery sometimes joins with the ophthalmic and furnishes large frontal arteries.

The *anterior temporal* branch is sometimes larger than the posterior, and passing backwards over the vertex of the head, communicates with the occipital.

The *transverse artery of the face* varies in size; occasionally it is much larger than usual, and takes the place of a defective facial artery. In some instances the transverse artery arises directly from the external carotid.

VII. INTERNAL MAXILLARY ARTERY.

The internal maxillary or deep facial artery, the larger of the two terminal branches of the external carotid, is concealed by the parotid gland at its origin below the condyle of the jaw; it curves horizontally forwards

between the jaw and the internal lateral ligament of the temporo-maxillary joint, then passes obliquely forwards and upwards on the outer surface of the external pterygoid muscle (not unfrequently beneath and within it), and opposite the interval between the two heads of that muscle, bends inwards to the spheno-maxillary fossa, where it ends by division into a number of branches.

To facilitate the arrangement of its numerous branches, this artery may be considered in three parts, viz. : 1, the part between the jaw and internal lateral ligament ; 2, the part in contact with the external pterygoid muscle ; and, 3, the part in the spheno-maxillary fossa.

Fig. 258.

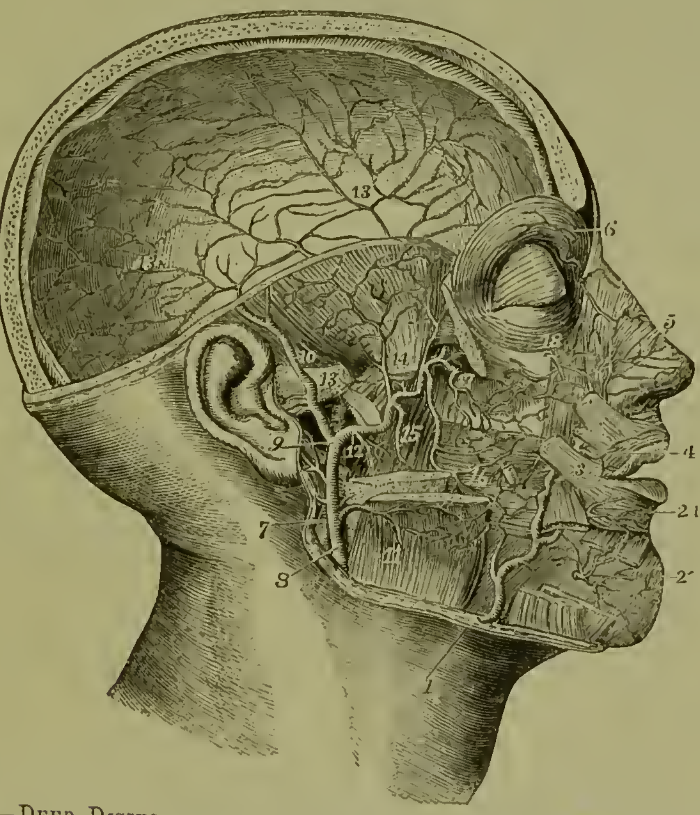


Fig. 258.—Deep Dissection of the Head and Face, to show the Internal Maxillary Artery and its Branches (from Tiedemann). $\frac{1}{3}$

The right half of the calvarium, the zygomatic arch, and the upper part of the lower jaw have been removed ; the external pterygoid muscle and some of the superficial muscles of the face have been divided, and the internal pterygoid and buccinator muscles are exposed : 1, facial artery, rising over the edge of the lower jaw ; 2, inferior labial branches ; 2', deep mental branch of the inferior maxillary artery ; 3, facial artery continued ; 4, superior coronary of the facial ; 5, lateral nasal branch ; 6, frontal branch of the ophthalmic artery, giving descending twigs to communicate with the angular branch of the facial and with the dorsal nasal ; 7, internal carotid artery ; 8, external carotid artery at the place where it passes through the parotid gland, which has been removed ; 9, division of the external carotid artery into superficial, temporal, and internal maxillary arteries ; 10, superficial temporal ; 11, masseteric branch of the external carotid artery ; 12, superiorly the trunk of the internal maxillary or deep facial artery, and inferiorly its inferior maxillary branch ; 13, placed on the zygoma, points to the middle meningeal branch, and above on the dura mater to its distribution ; 14, placed on the lower part of the temporal muscle separated from the coronoid process of the jaw, indicates the deep temporal branches of the artery ; 15, pterygoid branches ; 16, buccal artery ; 17, posterior superior dental, and deepest part of the internal maxillary artery where it enters the spheno-maxillary fossa ; 18, branches of the infra-orbital artery issuing upon the face.

Branches.—A. *Branches of the first part.*—The branches of the first part of the artery all pass through osseous foramina.

(*a*) The *tympanic branch*, of small size and variable in origin, passes deeply behind the articulation of the lower jaw, and enters the fissure of Glasser, supplying the laxator tympani muscle, and the tympanic cavity, where it ramifies upon the membrana tympani. It anastomoses in the tympanum with the stylo-mastoid and Vidian arteries.

(*b*) The *middle* or *great meningeal* artery, by far the largest of the arteries which supply the dura mater, passes directly upwards under cover of the external pterygoid muscle, and enters the skull by the spinous foramen of the sphenoid bone. Within the cranium, it ascends to the anterior inferior angle of the parietal bone, and divides into numerous branches, which ramify in deep arborescent grooves on the inner surface of the bones, some passing upwards over the parietal bone as high as the vertex, and others backwards even to the occipital bone.

Immediately on entering the cranium the meningeal artery gives minute branches to the ganglion of the fifth nerve and to the dura mater near the sella turcica, and a small twig which enters the hiatus Fallopii, and anastomoses with the stylo-mastoid branch of the posterior auricular artery. It also inosculates with branches of the ophthalmic artery.

The middle meningeal artery is accompanied by two veins.

(*c*) The *small meningeal* artery, usually arising from the preceding branch, enters the skull through the foramen ovale, to supply the dura mater in the middle fossa.

(*d*) The *inferior dental artery*, passing downwards, enters the dental canal along with the inferior dental nerve, and subsequently escapes on the face by the mental foramen. As it enters the canal, it gives off the *mylo-hyoid* branch, which, with the nerve bearing the same name, runs in a groove on the inner surface of the jaw, below the dental foramen, and ramifies on the under surface of the mylo-hyoid muscle. In its course through the bone, the inferior dental artery gives off small offsets, which ascend to enter the minute apertures in the extremities of the fangs of the teeth, and supply the pulp of each; and before emerging at the mental foramen, it sends forwards a branch which supplies the incisor teeth and inosculates with its fellow of the opposite side. The terminal or facial branches anastomose with the inferior coronary and submental arteries.

B.—*Branches of the second part.*—The branches of this part are chiefly distributed to muscles, and are named muscular.

(*a*) The *deep temporal* branches, two in number (anterior and posterior), ascending between the temporal muscle and the cranium, supply that muscle, and anastomose with the branches of the other temporal arteries, and with minute branches of the lachrymal artery, through small foramina in the malar bone.

(*b*) The *pterygoid* branches, small, short offsets, irregular in number and origin, are distributed to the pterygoid muscles.

(*c*) The *masseteric* is a small but regular branch which passes from within outwards, above the sigmoid notch of the lower maxillary bone, to the deep surface of the masseter muscle. It is often joined at its origin with the posterior temporal branch.

(*d*) The *buccal* branch runs obliquely forwards upon the buccinator muscle with the buccal nerve; it is distributed to that and other muscles of the cheek, and anastomoses with the branches of the facial artery.

C. *Branches of the third part.*—These branches, like those of the first series, enter bony foramina or canals.

(*a*) The *alveolar* or *superior maxillary branch*, arising near the tuberosity of the maxillary bone, frequently in common with the infra-orbital branch, runs tortuously forwards upon the surface of the upper jaw, and gives off the *superior dental* and other branches which enter the foramina of the tuberosity, and supply the pulps of

the upper molar and bicuspid teeth, besides ramifying in the lining membran of the maxillary sinus. Other small branches supply the gums.

(*b*) The *infra-orbital* artery runs horizontally forwards into the infra-orbital canal, and having traversed that canal along with the superior maxillary nerve, emerges upon the face at the infra-orbital foramen.

Whilst still in the canal, it sends upwards into the orbit small branches, which enter the inferior rectus and the inferior oblique muscle of the eye and the lachrymal gland, and others downwards to supply the front teeth. On the face it gives branches upwards, to the lachrymal sac and inner angle of the orbit, anastomosing with the nasal branches of the ophthalmic and facial arteries, and sends other branches downwards, beneath the levator labii superioris, which join the ramifications of the transverse facial, buccal, and superior coronary arteries.

(*c*) The *descending* or *superior palatine* artery descends perpendicularly through the posterior palatine canal, with the palatine nerve, and runs along the hard palate. In front it ends in a small vessel which ascends through the incisor foramen, and anastomoses with the artery of the septum. While descending in the canal, this artery sends off twigs through the bone, which communicate on the soft palate with the ascending palatine artery.

(*d*) The Vidian branch traverses the Vidian canal with the nerve of the same name; it is distributed to the Eustachian tube and the top of the pharynx, and sends a small vessel into the tympanum.

(*e*) The *pterygo-palatine*, a very small branch, passes backwards through the pterygo-palatine canal to reach the top of the pharynx, to which, and to the Eustachian tube and sphenoidal cells, it is distributed.

(*f*) The *nasal* or *spheno-palatine* artery enters the spheno-palatine foramen, and divides into two or three branches, some of which ramify extensively over the spongy bones, while others supply the posterior ethmoidal cells and the antrum. One long branch, the *artery of the septum*, runs forwards along the septum nasi, ends in a small vessel which enters the incisor foramen, and inosculates with the descending palatine artery.

Peculiarities.—*Origin.*—The internal maxillary artery is very constant in its place of origin. It has, however, been seen to arise from the facial.

Course.—The artery often passes under cover of the external pterygoid muscle, crossing the inferior maxillary division of the fifth nerve. It has likewise been observed to issue from under cover of the external pterygoid by piercing the middle of that muscle. When the artery is placed beneath the muscle, it has been found lodged in a notch in the posterior margin of the external pterygoid plate, and bound down by fibrous structure.

Branches.—The *middle meningeal* artery occasionally furnishes the lachrymal artery (usually an offset of the ophthalmic),—a peculiarity which may be looked on as resulting from the enlargement of an ordinary anastomosing branch.

In a case in which the internal carotid artery was wanting, two tortuous branches from the internal maxillary entered the skull by the foramen rotundum and foramen ovale, to supply its place. (Quain, "On the Arteries," pl. 13, fig. 8.)]

VIII. Ascending Pharyngeal Artery.

The pharyngeal artery, long and slender, the smallest branch of the external carotid which has received a distinctive designation, arises most commonly from half an inch to an inch above the origin of the external carotid; and in its straight course upwards rests on the rectus capitis anticus, close to the surface of the pharynx, between it and the internal carotid artery, and is thus directed up towards the base of the skull.

Branches.—These are very small, and may be divided into three sets, viz., those to the pharynx; a set directed outwards; and meningeal branches.

(*a*) The *pharyngeal* branches pass inwards, for the most part, to the pharynx. One or two small and variable branches ramify in the middle and inferior constrictor muscles. Higher up than these is a larger and more regular branch, which runs

upon the upper constrictor, and sends small ramifications to the Eustachian tube, and to the soft palate and tonsil.

The last mentioned, or *palatine* branch, is sometimes of considerable size, and supplies the soft palate, taking the place of the inferior palatine branch of the facial artery, which in such cases is small. It divides into an anterior and a posterior twig, both of which anastomose with their fellows of the opposite side in the middle line.

Fig. 259.

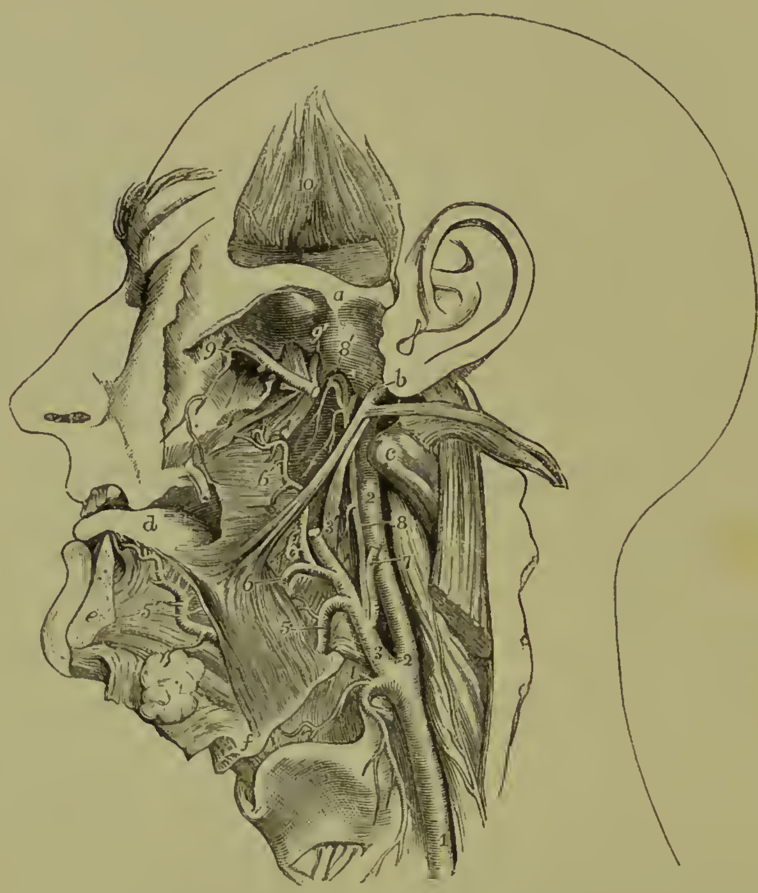


Fig. 259.—Deep View of the Lingual and Pharyngeal Arteries (from R. Quain). $\frac{1}{3}$

In the preparation from which this drawing has been taken half the lower jaw has been removed, and the tongue has been drawn forwards between the teeth; the external pterygoid muscle has been removed and the temporal muscle has been turned up from within the zygoma: *a*, the root of the zygoma, above the glenoid cavity; *b*, placed on the lobe of the ear, points by a line to the styloid process, from which the stylo-glossus and stylo-pharyngeus are seen passing downwards and forwards, and the stylo-hyoid detached from the hyoid bone is thrown backwards with the digastric muscle; *c*, transverse process of the atlas; *d*, upper surface of the tongue; *e*, sawn surface of the symphysis of the lower jaw; *f*, the angle of the hyoid bone; 1, left common carotid artery; 2, internal carotid artery; 3, external carotid artery; 3′, placed on the stylo-pharyngeus muscle, points by a line to the upper part of the external carotid artery divided where it enters the parotid gland; 4, superior thyroid artery, its laryngeal branch passing upon the thyro-hyoid membrane; 5, lingual artery about to pass within the hyo-glossus muscle; 5′, placed on the genio-hyo-glossus, points to the continuation of the lingual artery in the ranine; 6, the trunk of the facial artery cut short; 6′, its tonsillar and pharyngeal branches; 7, occipital artery cut short; 8, ascending pharyngeal artery; 8′, its upper part turning down upon the pharynx; 9, internal maxillary artery as it passes into the spheno-maxillary fossa, and gives the posterior dental and the infra-orbital arteries; 9′, middle meningeal artery; 10, placed on the deep surface of the temporal muscle, which is turned up and shows some cut branches of the deep temporal arteries.

(*b*) The *external* branches, small and irregular, are distributed to the rectus anticus muscle, the first cervical ganglion of the sympathetic nerve, some of the cerebral nerves as they issue from the skull, and to lymphatic glands. Some of them anastomose with the ascending cervical branch of the subclavian artery.

(*c*) The *meningeal* branches are terminal twigs, which pass through the foramen lacerum posticum to end in the dura mater.

Peculiarities.—This artery varies greatly in its place of origin from the carotid. It occasionally springs from another source, as from the occipital or internal carotid, and, in a few instances, it has been seen double.

INTERNAL CAROTID ARTERY.

The internal carotid artery is distributed to the brain, to the eye with its appendages, and in part to the forehead. It extends directly upwards from the termination of the common carotid artery, opposite the upper border of the thyroid cartilage, to the carotid foramen of the temporal bone. Entering the cranial cavity through the carotid canal, it crosses the foramen lacerum medium, and turning upwards on the side of the sphenoid bone, it passes forwards on the carotid groove of that bone. Thence it turns abruptly upwards on the inner side of the anterior clinoid process, and divides opposite the inner end of the Sylvian fissure of the brain, into the anterior and middle cerebral arteries.

In the neck, the internal carotid artery varies in length according to the height of the division of the common carotid. It rests on the rectus anticus major muscle, and has the pharynx and tonsil on its inner side. The internal jugular vein is in contact with it as far as the base of the skull, lying on its superficial and posterior aspect : and placed more deeply behind it are the vagus nerve and main trunk of the sympathetic. At its commencement the artery is covered only by the sterno-mastoid muscle, by the platysma myoides, and by fascia, and lies to the outer side of the external carotid. It soon, however, becomes concealed by the parotid gland, and lies internal and posterior to the external carotid trunk, and is crossed first by the occipital artery, and by the hypoglossal nerve and the digastric and stylo-hyoid muscles, three structures which lie superficial to both carotid arteries ; and higher up, by the styloid process, the stylo-pharyngeus muscle and the glosso-pharyngeal nerve, which, together with, in some cases, the pharyngeal branch of the vagus nerve, pass forwards between the external and internal carotid arteries.

Within *the cranium*, the internal carotid artery has a very tortuous course, curving forwards and inwards within the carotid canal, then turning upwards to reach the sphenoid bone, on which it is at first directed horizontally forwards, and afterwards resumes the vertical position on the inner side of the anterior clinoid process. In this part of its course the artery is accompanied by the carotid and cavernous plexuses of the sympathetic nerve. After leaving the carotid canal, it lies in the floor of the cavernous sinus, and in contact with it externally are the nerves which pass through the sphenoidal fissure. Opposite the anterior clinoid process it pierces the layer of dura mater which forms the roof of the sinus, and becomes invested with arachnoid membrane.

By the winding course of the internal carotid artery in the skull the brain is probably in some degree protected from the force of the pulsations with which the blood is propelled from the heart. Occasionally the artery presents considerable tortuosity before entering the carotid canal, especially in apoplectic subjects, the trunk having probably been elongated by the force of the pulsations.

The vertebral artery is similarly tortuous before entering the cranium.

Branches.—In the neck the internal carotid artery gives usually no branch. While within the carotid canal it sends a small offset to the tympanum, which anastomoses with the tympanic and stylo-mastoid arteries. Within the cavernous sinus some small branches proceed from it to supply the walls of the sinus and the adjacent dura mater.

Opposite the anterior clinoid process, the internal carotid gives off the *ophthalmic* artery; and at the Sylvian fissure of the brain, before dividing into the anterior and middle cerebral arteries, it gives off or is joined by the *posterior communicating* artery, a slender anastomotic branch which lies parallel to its fellow of the opposite side and unites the internal carotid with the posterior cerebral artery.

Peculiarities.—In very rare cases of abnormal arrangement of the arch of the aorta, the internal carotid artery has arisen as a primary trunk. A few examples are recorded of its entire absence.

The posterior communicating artery has been occasionally seen replaced by two very small vessels.

BRANCHES OF THE INTERNAL CAROTID ARTERY.

I. OPHTHALMIC ARTERY.

The *ophthalmic* artery, arising from the internal carotid artery by the side of the anterior clinoid process, enters the orbit by the foramen opticum, below and to the outer side of the optic nerve. It soon changes its direction, passing over the nerve to reach the inner wall of the orbit, along which it runs forwards, and terminates in branches which ramify on the forehead and side of the nose.

Branches:—

(*a*) The *lachrymal* artery, arising on the outer side of the optic nerve, passes forwards along the upper border of the external rectus muscle to the lachrymal gland, in which the greater number of its branches are distributed. Some of the branches pass onwards to the eyelids and conjunctiva, joining with other palpebral branches; and one or two delicate *malar* branches pierce the malar bone and reach the temporal fossa, where they join branches from the deep temporal arteries. The lachrymal artery has also branches of communication through the sphenoidal fissure with small offsets from the middle meningeal artery.

(*b*) The *central artery of the retina*, a very small vessel, pierces the sheath and substance of the optic nerve about a quarter of an inch behind its junction with the eyeball, and runs imbedded within it to the retina, in which it ramifies in minute branches. A very delicate vessel, demonstrable in the fœtus, passes forwards through the vitreous humour, to reach the posterior surface of the capsule of the crystalline lens.

(*c*) The *supra-orbital* branch ascends above the muscles, and coursing forwards to the supra-orbital notch, in company with the frontal nerve, terminates on the forehead. It distributes branches to the eyelids, and communicates with the temporal artery.

(*d*) The *ciliary* arteries are divisible into three sets, viz., short, long, and anterior ciliary. The *short* ciliary arteries, varying from twelve to fifteen in number, enclose the optic nerve as they pass forwards to reach the posterior aspect of the sclerotic coat, which they pierce, and enter the eyeball about a line or two from the entrance of the optic nerve. The *long* ciliary arteries, two in number, also enter the back of the eyeball, and then pass forwards, one on each side, between the choroid membrane and the sclerotic, as far as the ciliary ligament, where they divide into branches. The *anterior* ciliary arteries are derived from some of the muscular branches; they form a vascular circle around the fore part of the eyeball, and then

Fig 260.

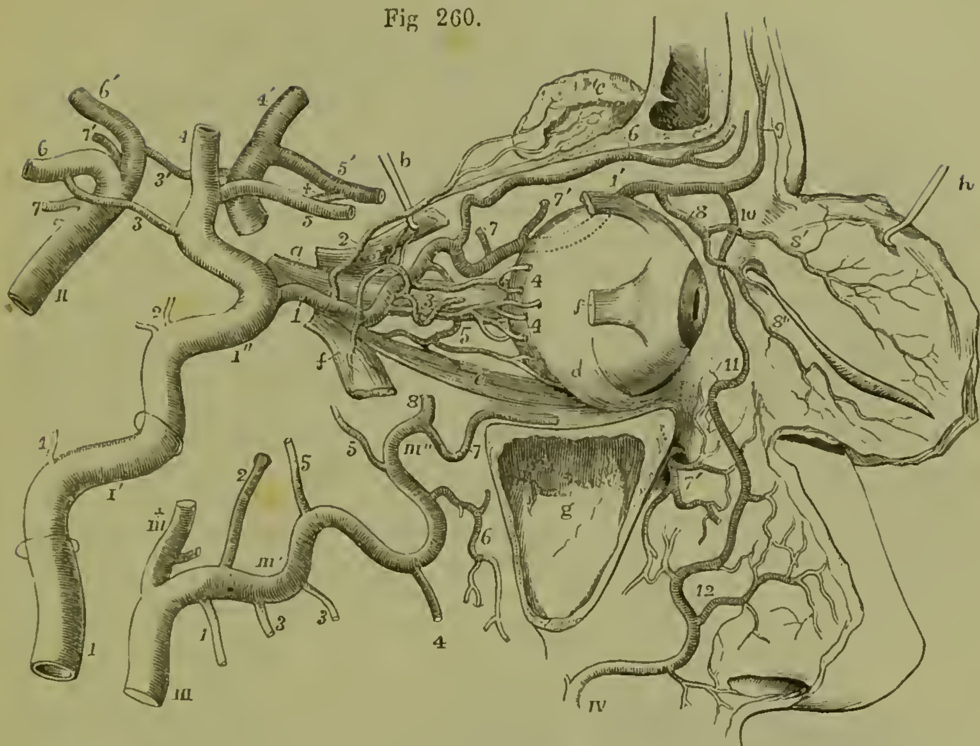


Fig. 260.—SEMIDIAGRAMMATIC VIEW OF THE ARTERIES OF THE ORBIT AND NEIGHBOURING PARTS, WITH THEIR BRANCHES AND ANASTOMOSES (founded on Hirschfeld and Leveillé, with additions).

The outer wall of the orbit has been removed, the sinus maxillaris is laid open, the eyelids are turned forwards, and the external and superior recti, and the superior oblique muscles have been partially removed. *a*, optic nerve ; *b*, hook, holding up the posterior part of the superior rectus muscle, the anterior part of which is left attached to the eyeball ; *c*, lachrymal gland, thrown up on the frontal bone ; *d*, insertion of the inferior oblique muscle ; *e*, inferior rectus ; *f*, *f*, anterior and posterior portions of the divided external rectus ; *g*, maxillary sinus ; *h*, hook, holding up the eyelids, of which the deep surface is exhibited.

I, internal carotid artery below the inferior aperture of the carotid canal of the temporal bone, which is indicated higher up by a ring surrounding the artery ; I′, the part of the artery situated within the temporal bone, a second ring indicating the place of the upper aperture of the temporal canal ; I″, the part of the artery situated on the sphenoid bone ; upon this artery, 1, twig to the mastoid cells and tympanum ; 2, twigs in the cavernous sinus ; 3, communicating to the posterior cerebral ; 4, middle cerebral ; 5, anterior cerebral.

II, basilar artery ; upon this artery, 6, posterior cerebral ; 7, superior cerebellar : the accented numbers, 3′, 4′, 5′, 6′, 7′, indicate, on the left side, the arteries already named under the same numbers on the right side, and with these and the anterior communicating branch marked by +, complete the Circle of Willis.

III, upper part of the external carotid artery dividing into III ×, the superficial temporal, and III′, III″, the internal maxillary artery ; upon the lattor artery, 1, inferior dental branch ; 2, middle meningeal ; 3, 3, masseteric and pterygoid branches ; 4, buccal ; 5, 5, anterior and posterior deep temporal ; 6, posterior superior dental ; 7, infraorbital ; 7′, branches of the same issuing upon the face ; 8, part of the internal maxillary, which turns into the spheno-maxillary fossa.

IV, facial artery, terminating at 11, in the angular, and giving off, at 12, the lateral nasal branches, and others which communicate with the infraorbital.

In the orbit the following numbers indicate the ophthalmic artery and its branches : 1, the ophthalmic artery at its origin from the internal carotid ; 1′, the same artery continued on the upper and inner side of the orbit ; 2, lachrymal branch ; 3, central artery of the retina ; 4, some of the ciliary arteries ; 5, 5, upper and lower muscular branches ; 6, supraorbital ; 7, 7′, posterior and anterior ethmoidal arteries ; 8, palpebral ; 8′, 8″, its superior and inferior divisions ; 9, frontal ; 10, nasal communicating with the angular of the facial.

pierce the sclerotic within a line or two of the margin of the cornea. All these ciliary arteries anastomose together within the eyeball, their distribution in which will be particularly described with the anatomy of the eyeball.

(*e*) The *muscular* branches, subject to much variety, usually arranged in an upper and lower set, supply the muscles of the orbit.

(*f*) The *ethmoidal* branches are two in number, a *posterior* and an *anterior*. They pass through the posterior and anterior internal orbital foramina, the latter in company with the nasal branch of the ophthalmic nerve; and both arteries, having furnished branches to the ethmoidal cells, enter the skull, supply the adjacent dura mater, and send branches through the cribriform lamella to the nose.

(*g*) The two *palpebral* branches, *superior* and *inferior*, arise near the front of the orbit, usually together, but soon diverge, one lying above, the other below the tendon of the orbicularis muscle at the inner angle of the eye; they form arches, one in each lid, and send branches to the caruncula lachrymalis and the lachrymal sac.

(*h*) The *nasal* branch courses forwards above the tendon of the orbicularis muscle to the root of the nose, where it ramifies, maintaining a free communication with the nasal and the angular branches of the facial artery.

(*i*) The *frontal* branch runs close to the preceding. but on reaching the margin of the orbit turns upwards on the forehead, where it anastomoses with the supraorbital artery.

Fig. 261.

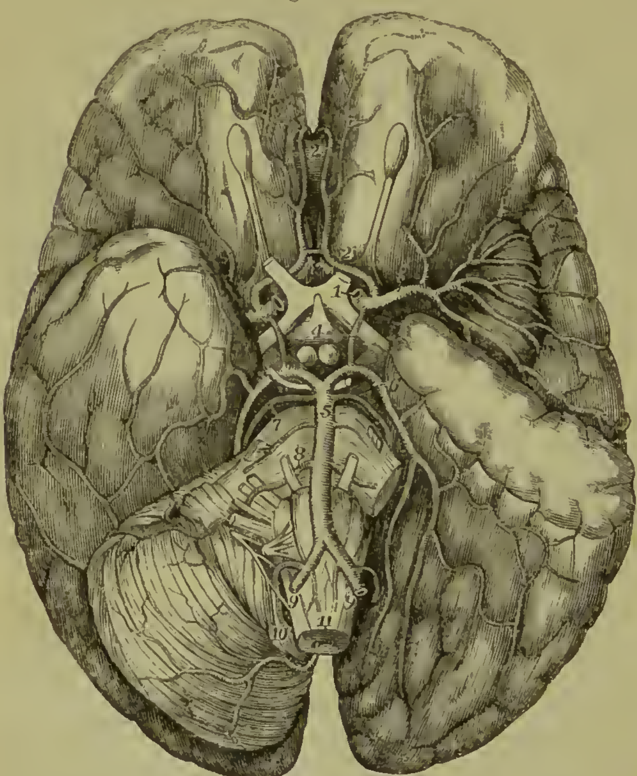


Fig. 261.—View of the Distribution of the Branches of the Internal Carotid and Vertebral Arteries to the lower parts of the Brain (altered from Hirschfeld and Leveillé). $\frac{1}{3}$

On the left side of the brain a portion of the middle lobe of the cerebrum has been removed so as to open up the fissure of Sylvius and expose the convolutions of the island of Reil; and the left half of the cerebellum has been removed to show the lower surface of the posterior cerebral lobe. 1, placed on the optic commissure, points to the divided stem of the left internal carotid artery where its cerebral distribution begins; 2, anterior cerebral branch, exposed fully by the removal of a portion of the left optic nerve; 2′, placed on the knee or anterior bend of the corpus callosum between its two arteries; ×, placed on the lamina cinerea in front of the optic commissure, marks the anterior communicating artery; 3, middle cerebral artery, passing into the fissure of Sylvius and distributing its branches over the convolutions of the island of Reil and others beyond; 4, placed between the infundibulum and the corpora albicantia, points by a line to the left posterior communicating artery; 5, basilar artery; 6, posterior cerebral artery, its distribution exposed on the left side by the removal of half of the cerebellum; 7, placed on the pons Varolii, points to the right superior cerebellar artery; 8, anterior inferior cerebellar artery; between 7, and 8, one of the largest of the transverse branches of the basilar artery; 9, 9, right and left vertebral arteries; 10, posterior inferior cerebellar arteries; 11, anterior spinal arteries.

II. ANTERIOR AND MIDDLE CEREBRAL ARTERIES.

The terminal branches of the internal carotid artery supply the anterior and greater part of the pia mater and brain.

The *anterior cerebral*, commencing at the subdivision of the internal carotid at the inner end of the fissure of Sylvius, turns forwards towards the middle line to reach the longitudinal fissure between the anterior lobes of the cerebral hemispheres, and is connected with the vessel of the opposite side by the *anterior communicating artery*, a branch not more than two lines in length. The two anterior cerebral arteries, lying close together, in the next place turn round the anterior border of the corpus callosum, run backwards on its upper surface, concealed by the cerebral hemispheres, and end by anastomosing with the posterior cerebral arteries. In their course they give numerous branches to the brain.

The *middle cerebral* artery, larger than the anterior, inclines obliquely outwards, taking the course of the fissure of Sylvius ; within this it divides into several branches, which ramify in the pia mater investing the surfaces of the anterior and middle lobes of the brain, and join with the branches of both the anterior and posterior cerebral arteries. Numerous small branches, without ramifying in the pia mater, turn upwards at once, and enter the brain at the anterior perforated spot, through which they reach the corpus striatum.

One or two *choroid* arteries, which sometimes arise directly from the internal carotid, passing backwards, enter the fissure between the middle lobe and the crus cerebri, to reach the descending cornu of the lateral ventricle, in which they are distributed to the choroid plexus.

PECULIARITIES.—In rare instances, the anterior cerebral arteries have united into a single trunk, like the basilar artery behind, and have again divided into a right and left artery. The anterior communicating artery is frequently double.

CIRCLE OF WILLIS.

A remarkable anastomosis exists between the branches of the vertebral and internal carotid arteries within the cranium, by which the circulation in the brain may be equalised, and any irregularity which might arise from the obliteration of one, or even two of the vessels, may speedily be remedied by a corresponding enlargement of the others. This anastomosis, known as the *circle of Willis*, results from a series of communications between the following branches. The anterior cerebral arteries are connected together, as already mentioned, in the longitudinal fissure by the anterior communicating artery. The right and left internal carotids, the trunks from which the anterior cerebral arteries arise, are united by the posterior communicating arteries to the posterior cerebral arteries, which arise behind from a single trunk—the basilar artery. Within or opposite to the area of this vascular circle are the following parts of the encephalon, viz., the commissure of the optic nerves, lamina cinerea, infundibulum and tuber cinereum, corpora albicantia, posterior perforated spot with part of the crura cerebri, and the origin of the third pair of nerves.

Frequently the posterior cerebral artery of one side arises by an enlarged posterior communicating artery from the internal carotid, and is connected only by a slender vessel with the basilar.

SUBCLAVIAN ARTERIES.

The subclavian artery is only the commencing portion of a long trunk which forms the main artery of the upper limb, and which is artificially divided for purposes of description into three parts—the *subclavian*, *axillary*, and *brachial* arteries.

The subclavian artery, arising on the right side from the extremity of the innominate stem, and on the left from the arch of the aorta, passes a short way up into the neck, arches outwards over the pleura, and rests between the scalenus anticus and scalenus medius muscles on the first rib. At the outer border of the first rib it ceases to be called subclavian, and is continued into the axillary artery.

Each subclavian artery is conveniently divided into three parts,—the *first* part extending from the origin of the vessel to the inner border of the anterior scalenus muscle; the *second* consisting of the portion of the vessel situated behind that muscle; and the *third* reaching outwards to the external border of the first rib. In examining each of these portions in detail, it will be necessary in the first part to give separate descriptions for the right and the left sides, as there is a material difference in the anatomy of the two vessels.

The first part of the right subclavian artery commences close to the trachea, at the division of the innominate artery, behind the upper part of the sterno-clavicular articulation, and ends at the inner margin of the anterior scalenus muscle. Separating from the carotid artery, it arches upwards and outwards, and ascends above the level of the clavicle to an extent which varies in different cases. It is deeply placed, being covered by the platysma, the sterno-mastoid, the sterno-hyoid and sterno-thyroid muscles, and the deep cervical fascia. It is in contact with the pleura inferiorly, and is separated by an interval from the longus colli muscle behind.

Relation to Veins.—The *subclavian* vein lies lower than the first part of the right subclavian artery, close under the clavicle. In its course to join this vein, the *internal jugular* passes in front of the artery near the scalenus muscle, as do also, nearer the middle line, the *anterior jugular* and a *vertebral* vein.

Relation to Nerves.—The *vagus* nerve passes in front of the artery on the inner side of the internal jugular vein, and its *recurrent laryngeal* branch, turning round below the artery, ascends behind. Some cardiac branches of the *sympathetic* nerve pass down over the artery.

The first part of the left subclavian artery arises from the upper surface of the arch of the aorta, at the left end of its transverse portion, and ascends to the margin of the first rib, behind the insertion of the anterior scalenus muscle. It is, therefore, longer than the first part of the right subclavian, and ascends at first almost vertically out of the chest, instead of arching, like that vessel, outwards across the neck. It is at first overlapped by the left lung, and is covered in front and on the left side by the pleura; it rests on the longus colli muscle, and lies, for a short space, in front of the œsophagus (here deviating to the left side), and the thoracic duct. To the inner or right side of the vessel are situated the left carotid and trachea, and further up the œsophagus and the thoracic duct.

Relation to Veins.—The internal jugular vein is immediately before the artery, where it turns outwards from the thorax, close to the scalenus muscle; and the left innominate vein is likewise anterior to it.

Relation to Nerves.—The *pneumogastric* nerve is anterior to the first part of the left subclavian artery, and parallel with it, the recurrent branch on this side turning round below the arch of the aorta. The *phrenic* nerve

Fig. 262.

Fig. 262.—View of the Right Common Carotid and Subclavian Arteries, with the origin of their branches and their relations (from R. Quain). $\frac{1}{3}$

For the description of the upper part of this figure, see p. 342. The following explanation relates to the subclavian artery and its branches: 8, the first part, 8′, the third part, of the arch of the subclavian artery; 8″, the subclavian vein, shown by the removal of a portion of the clavicle; 9, is placed on the scalenus anticus muscle in the angle between the transverse cervical and supra-scapular branches of the thyroid axis; 10, outer part of the supra-scapular artery; 10′, transverse cervical branches passing into the deep surface of the trapezius; 10″, the posterior scapular artery, represented as rising directly from the third part of the subclavian artery, and passing through the axillary plexus of nerves and under the levator anguli scapulæ; 11, on the scalenus anticus muscle, points to the inferior thyroid artery, near the place where the ascending muscular artery of the neck is given off; the phrenic nerve lies on the muscle to the outside; *i*, the supra-sternal twig of the supra-scapular artery.

descends over the artery along the inner margin of the scalenus muscle, immediately outside the thyroid axis. The *cardiac* nerves of the left side, descending from the neck, are close to the artery.

THE SECOND PART OF THE SUBCLAVIAN ARTERY, the short portion concealed by the anterior scalenus muscle, forms the highest part of the arch described by the vessel across the neck. Somewhat less deeply placed than the first part, it is covered by the platysma and the sterno-mastoid muscle, with layers of the cervical fascia. Behind, it rests against the middle scalenus muscle ; and below, it lies on the pleura.

Relation to Veins and Nerves.—The subclavian vein is lower than the artery, and is separated from it by the anterior scalenus muscle. The phrenic nerve, which descends obliquely inwards over that muscle, usually crosses the first part of the subclavian artery of the left side close to the muscle, while on the right side, not having quite reached the margin of the muscle at the level of the artery, it is usually separated by the muscle from the second part of the artery.

THE THIRD PART OF THE SUBCLAVIAN ARTERY lies in a small triangular space, the sides of which are formed by the omo-hyoid muscle and clavicle, and the base by the anterior scalenus muscle ; the omo-hyoid is in some instances immediately over the artery. The subclavian artery is nearer to the surface here than elsewhere, being covered only by the platysma and layers of the cervical fascia, but towards its termination it becomes deeper, sinking under the clavicle and the subclavius muscle.

Relation to Veins.—The *subclavian* vein continues to be anterior to, and lower than the artery. The *external jugular* vein lies over the artery, and receives on the outer side from the shoulder the two veins which accompany the supra-scapular and transverse cervical arteries. The veins in some cases form a sort of plexus over the artery.

Relation to Nerves.—Above the vessel are placed the large *brachial* nerves, the lowest cord formed by the union of the last cervical and the first dorsal nerve being behind and in contact with it. The small nerve of the *subclavius* muscle passes down over the artery, and the space which lodges the artery is crossed in front by the superficial descending (clavicular) branches from the *cervical* plexus of nerves.

BRANCHES.—Four branches are usually described as arising from each subclavian artery. Of these, three, namely, the *vertebral*, the *internal mammary*, and the *thyroid axis*, generally spring close together from the first part of the artery, near the inner side of the anterior scalenus muscle; while the fourth branch, the *superior intercostal*, is usually found internal to that muscle on the left side, but arising under cover of it, from the second part of the artery on the right.

The vertebral artery springs from the upper and back part of the subclavian, and ascends in the neck to reach the interior of the skull ; the internal mammary proceeds from the lower side of the vessel, and descends into the fore part of the chest and abdomen ; the thyroid axis arises from the front of the artery, and divides into three branches, one of which, the *inferior thyroid*, is distributed in the fore part of the neck, whilst the other two, the *suprascapular* and the *transverse cervical*, pass outwards across the neck to the shoulder ; lastly, the superior intercostal and deep cervical arise by a common stem from the back part of the artery, and pass into the upper part of the thoracic wall and the posterior muscles of the neck. The deep cervical is reckoned by some writers as a fifth branch of the subclavian artery, but it usually rises in common with the superior intercostal artery.

Another branch, in the great majority of instances, arises from the third part of the artery. This is most frequently the *posterior scapular* artery, a branch which otherwise is derived from the transverse cervical, one of the divisions of the thyroid axis. This circumstance is of surgical interest, as the third part of the subclavian artery is the portion of the vessel usually tied for axillary aneurism. As the right subclavian artery is likewise accessible to the surgeon in its first part, it is proper to mention that the distance between the origin of the vessel and its first branch is usually between half an inch and an inch, and that it very rarely is less than half an inch or more than an inch and a half.

Peculiarities.—The variations in origin of the subclavian arteries have been considered along with the peculiarities of the arch of the aorta.

Course.—The height to which these vessels reach in the neck is liable to some variation. Most commonly the artery crosses the neck a little higher than the clavicle, but it is sometimes placed as high as an inch or even an inch and a half above the level of that bone. The greater extent of elevation above the clavicle, however, is especially seen in the artery of the right side. Occasionally the subclavian artery perforates the anterior scalenus muscle, and in a few rare cases it has been seen altogether in front of the muscle, and close to the subclavian vein. That vein has been also seen to pass with the artery behind the scalenus muscle.

Branches.—Besides the variation in amount of the branches already referred to, it may be noticed that, in a few cases, one or more of the three first branches have been found moved inwards from their usual position, or outwards to another division of the subclavian. Sometimes two, and much more rarely three branches arise from the third part of the vessel.

BRANCHES OF THE SUBCLAVIAN ARTERY.

I. Vertebral Artery.

The vertebral artery, which is usually the first and largest branch of the subclavian, arising from the upper and back part of that vessel, passes upwards and a little backwards, and enters the transverse foramen of the sixth cervical vertebra—not unfrequently that of some higher vertebra. The vessel then ascends in a vertical direction through the series of foramina of the transverse processes, as far as to the upper border of the axis ; there it inclines outwards to reach the corresponding foramen of the atlas, and after passing through that aperture winds backwards and inwards in the groove on the neural arch of that vertebra, and, piercing the dura mater, enters the skull through the foramen magnum. Finally, it proceeds upwards and forwards, and turning round from the side to the front of the medulla oblongata on the basilar process of the occipital bone, unites with the vessel of the opposite side, at the lower border of the pons Varolii, to form the basilar artery.

At its commencement, the vertebral artery lies behind the internal jugular vein, and on approaching the vertebræ passes between the longus colli and the scalenus anticus muscle. On the left side, the thoracic duct in ascending crosses in front of the vessel from within outwards.

While within the foramina of the cervical vertebræ, the artery is accompanied by a plexus of the sympathetic nerves and by the vertebral vein, which, as the vessels issue from the foramen of the sixth vertebra, is in front of the artery : the cervical nerves as they emerge from the intervertebral foramina lie behind it. The sub-occipital nerve passes out beneath

it, where it lies on the groove of the atlas, and at that point the artery is covered by the superior oblique muscle.

Within the skull it turns round the side of the medulla oblongata, between the origin of the hypoglossal nerve and the anterior root of the sub-occipital, and then lies between the anterior surface of the medulla and the basilar process of the occipital bone.

Fig. 263.

Fig. 263. — Deep Dissection of the Subclavian Artery on the right side, showing the origin and course of the Vertebral Artery (from Tiedemann). $\frac{1}{3}$

a, Upper part of the sterno-mastoid muscle, its clavicular part divided below; *b*, spinous process of the axis; *c*, superior oblique muscle; *d*, placed on the inferior oblique muscle, points by a line to the posterior arch of the atlas vertebra; *e*, semi-spinalis colli; *f*, placed on the longus colli, points to the transverse process of the sixth cervical vertebra; *g*, on the first rib, points to the scalenus anticus muscle cut near its attachment; 1, innominate artery; 2, right common carotid; 3, right subclavian; below it, the origin of the internal mammary artery; above it, 4, the thyroid axis, its branches cut short; 5, vertebral artery, passing up through the canal of the transverse processes and giving branches to the muscles; 5′, placed on the rectus major, points to its horizontal part on the arch of the atlas; 6, placed on the lower part of the divided scalenus medius, points to the trunk of the deep cervical and first intercostal arteries; 6′, placed on the scalenus medius, points to the deep cervical artery; 7, occipital artery emerging from below the sterno-mastoid and other muscles attached to the mastoid process.

Branches.—A. *Cervical branches:*

(*a*) In the neck, the vertebral artery sends off at different points of its course several small branches named *spinal* arteries. Each of these entering the spinal canal through an intervertebral foramen divides into two branches; one of these passes along the roots of the spinal nerves, supplying the spinal cord and its membranes, and anastomoses with the other spinal arteries; the other branch ramifies on the back part of the bodies of the vertebræ in the same manner as similar branches derived from the intercostal and lumbar arteries.

(*a*) *Muscular* branches of variable size are distributed to the deep-seated cervical muscles.

B. *Cranial branches :*

(*a*) The *posterior meningeal* artery is a small branch which arises opposite the foramen magnum, and ramifies between the dura mater and the bone in the occipital fossa, and upon the falx cerebelli. There are sometimes two of these small vessels.

(*b*) The *posterior spinal* artery, arising at an obtuse angle from the vertebral, inclines backwards round the medulla oblongata to reach the back part of the spinal cord; aided by reinforcements from small arteries which ascend upon the cervical and dorsal nerves through the intervertebral foramina, it may be traced along the cord, lying behind the roots of the nerves, as a minute tortuous vessel, or rather a series of little inosculating vessels, as far as the second lumbar vertebra, where it terminates in ramifications on the cauda equina.

(*c*) The *anterior spinal artery*, somewhat larger than the preceding, arises near the end of the vertebral artery, and descends obliquely in front of the medulla oblongata. Immediately below the foramen magnum, it unites with the corresponding vessel of the opposite side, so as to form a single trunk, which descends a short distance only along the middle line in front of the spinal cord, forming the upper part or commencement of the anterior median artery of the cord. This anterior spinal branch of the vertebral artery supplies therefore only the upper part of the cord; the remainder being provided with a series of small arteries, which are derived in the neck from the vertebral and inferior thyroid arteries, in the back from the intercostal, and below this from the lumbar, ilio-lumbar, and lateral sacral arteries. These small vessels enter the spinal canal at irregular intervals through the intervertebral foramina, and passing along the roots of the nerves, communicate with each other along the middle line by means of ascending and descending branches; so that, by a succession of anastomoses, a very slender single vessel, of varying thickness, named the *anterior median artery*, appears to extend from the one end to the other of the cord. This vessel, or chain of inosculating vessels, supplies the pia mater and the substance of the cord—some entering the anterior median fissure. At the lower end of the spinal cord it sends branches downwards on the cauda equina.

On a part of the spinal cord near the lower end, and in front of the posterior roots of the nerves, may be found another small artery, about equal in size to the anterior spinal.

(*d*) The *posterior inferior cerebellar artery*, the largest of the branches, arises from the vertebral near the pons, and sometimes from the basilar artery: it turns backwards and outwards, between the hypoglossal and pneumogastric nerves, over the restiform body and near the side of the opening of the fourth ventricle, to reach the under surface of the cerebellum. Here, running backwards between the inferior vermiform process and the hemisphere, it divides into two branches: one of which continues backwards in the sulcus between the hemispheres; while the other, turning outwards, ramifies on the under surface of the cerebellum as far as its outer border, over which the ultimate divisions of each branch anastomose with those of the superior cerebellar arteries. This artery partly supplies the hemisphere and the vermiform process, and gives branches to the choroid plexus of the fourth ventricle.

Peculiarities.—*Origin.*—The right vertebral artery has been seen to arise from the common carotid of the same side, in some of those cases in which the right subclavian has been given as a separate vessel from the posterior part of the aorta. In very rare instances, the right vertebral artery arises from the aorta.

The left vertebral artery is not unfrequently derived from the aorta, in which case it generally arises between the left carotid and subclavian arteries, but sometimes it is the last of the branches from the arch.

The left vertebral artery in a few instances, and the right vertebral in one, have been found to arise by more than a single root; and an example of three roots to a vertebral artery has been placed on record. (R. Quain, plate 24, fig. 2.) Two roots may proceed from the subclavian artery, or one from the subclavian and one from the aorta.

Course.—Instead of entering the foramen of the sixth vertebra, the vertebral artery of one side not unfrequently enters higher up, through the foramen of the fifth, or

fourth, or more rarely of the third vertebra, or even, according to several anatomists, of the second. On the other hand, the vertebral artery has been seen to enter the foramen of the seventh vertebra.

Branches.—In the neck, the vertebral artery has been found, though very rarely, to give branches which are usually derived from the subclavian, such as the superior intercostal and the inferior thyroid.

BASILAR AND POSTERIOR CEREBRAL ARTERIES.

The *basilar artery*, the single trunk formed by the junction of the right and left vertebral in the middle line, extends from the posterior to the anterior border of the pons Varolii, along the median groove of which it lies under cover of the arachnoid. The length of this artery is therefore about equal to that of the pons, at the anterior border of which it divides into two terminal branches, the posterior arteries of the cerebrum.

BRANCHES.—Besides numerous small branches to the substance of the pons, the basilar artery gives off the following :—

(*a*) The *transverse* arteries, several on each side, pass directly outwards. One, the *artery of the acoustic nerve*, accompanies that nerve into the internal auditory meatus and labyrinth of the ear.

(*b*) The *anterior inferior cerebellar* arteries pass backwards, one on each side, to the anterior part of the under surface of the cerebellum, anastomosing with the inferior cerebellar branches of the vertebral arteries.

(*c*) The *superior cerebellar* arteries arise so close to the bifurcation of the basilar, that this artery is described by several anatomists as dividing into four branches. Each one turns backwards and outwards immediately behind the third nerve, and entering the groove between the pons Varolii and the crus cerebri, turns round the latter, close to the fourth nerve, to reach the upper surface of the cerebellum, where it divides into branches. Of these some extend outwards, and one or more backwards along the superior vermiform process, to reach the circumference of the cerebellum, where they anastomose with the branches of the inferior cerebellar arteries; while others run inwards to supply the vermiform process and the valve of Vicussens, and in part the velum interpositum.

The *posterior cerebral* artery on each side, resulting from the division of the basilar, passes outwards, parallel to the superior cerebellar artery, and separated from it at its origin by the third nerve, which comes forwards between the two vessels. It turns backwards round the crus cerebri, and then runs outwards and upwards on the under surface of the posterior lobe of the cerebrum, passing near the posterior extremity of the corpus callosum. It divides beneath the posterior lobe into many branches, which ramify upon the under, median, and outer surfaces, and anastomose with the other cerebral arteries.

BRANCHES.—Immediately after its origin the posterior cerebral artery gives off numerous small parallel branches, which perforate the substance of the brain between the crura, at the point which is called from this circumstance the posterior perforated spot. As it turns backwards, a short distance from its origin, this artery is joined by the *posterior communicating artery*, and in this way contributes as already described (p. 363) to form the circle of Willis. Lastly, the posterior cerebral gives origin to a small branch, the *posterior choroid*, which, arising external to the junction of the communicating artery, turns backwards over the crus cerebri and the tubercula quadrigemina, supplying these with branches, and ending in the velum interpositum and choroid plexus in the interior of the brain.

PECULIARITIES.—Traces of a septum are sometimes found in the interior of the basilar artery. (Davy, "Researches," &c., vol. i. p. 301.) This trunk has also been found perforated by a small foramen, owing to a partial fissuring of the vessel along the median line.

The posterior cerebral artery is occasionally given off on one side from the internal carotid artery.

II. THYROID AXIS.

The thyroid axis springs from the fore part of the subclavian artery, close to the inner side of the anterior scalenus muscle. It is a short thick trunk, and receives the name of "axis," because, at a line or two from its origin, it divides into branches, which diverge in different directions, viz., the inferior or ascending thyroid, the suprascapular, and a third branch, which is either the transverse cervical, or one of the branches into which that artery, when present, divides, viz., the superficial cervical.

Peculiarities.—The thyroid axis has been known to arise beyond the scalenus anticus muscle. It may be associated at its origin with another branch; thus, it sometimes gives origin to the internal mammary, and has been known to give origin to the vertebral, superior intercostal, or deep cervical arteries.

1. The Inferior Thyroid Artery passes directly upwards, resting on the longus colli muscle, and after a short course bends inwards and downwards behind the sheath of the large cervical vessels, and also behind the sympathetic nerve (the middle cervical ganglion of which, when present, often rests upon this vessel). The artery then makes another curve in the opposite direction, and is distributed to the under part of the thyroid body. Its branches communicate freely with those of the superior thyroid artery, and with the corresponding artery of the other side.

Branches.—(*a*) The *ascending cervical* branch arises at the point where the inferior thyroid turns inwards behind the carotid artery; it proceeds upwards, close to the phrenic nerve, on the line of separation between the scalenus anticus and rectus anticus major, giving *muscular* branches to both, and a few which pass transversely outwards across the neck. These muscular branches communicate with others sent outwards from the vertebral artery. To the spinal canal the ascending cervical artery sends one or two branches (*spinal branches*), which enter the intervertebral foramina along the cervical nerves, and assist in supplying the bodies of the vertebræ, and the spinal cord and its membranes.

(*b*) A *laryngeal* branch of irregular size is usually supplied by the inferior thyroid artery; it ascends on the trachea and the back of the larynx, and is distributed to the muscles and mucous membrane in that situation.

(*c*) *Tracheal* branches ramify over the trachea, and anastomose below with the bronchial arteries.

(*d*) Œsophageal branches are given off, and one or more descend upon the trachea into the chest.

Peculiarities.—*Origin.*—The inferior thyroid artery occasionally arises as an independent branch from the subclavian artery, and rarely from the common carotid or the vertebral. Instances have occurred—very rarely, however—of the presence of two inferior thyroid arteries, one passing over the common carotid artery.

The ascending cervical artery is occasionally derived from the subclavian or from one of the branches of that vessel, as from the transverse cervical or the suprascapular, or from a trunk common to those two arteries. It is sometimes much larger than usual, and takes the place of the occipital artery. A branch from it not unfrequently compensates for the small size of the deep cervical artery.

2. The Suprascapular Artery (transverse scapular, or transverse humeral), a smaller vessel than the transverse cervical, arises almost constantly from the thyroid axis, and runs from within outwards deeply at the root of the neck. At first it descends obliquely towards the clavicle, resting upon the scalenus anticus, and covered by the sterno-mastoid

muscle ; it then crosses the subclavian artery, and continues transversely outwards behind and parallel with the clavicle and subclavius muscle, and below the posterior belly of the omo-hyoid muscle. Approaching the upper margin of the scapula, under cover of the trapezius muscle, it inclines

Fig. 264.

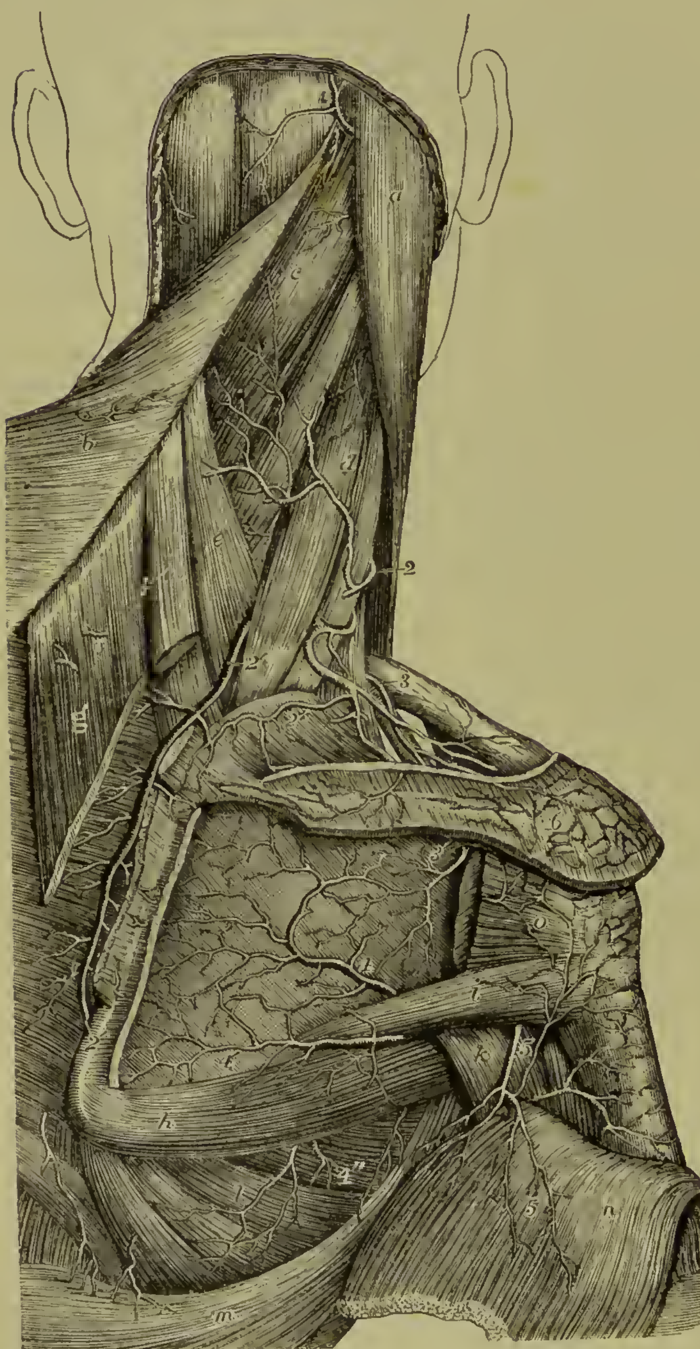


Fig. 264.—View of the Anastomoses of Arteries on the Shoulder and Dorsum of the Scapula (from Tiedemann). ½

a, sterno-mastoid muscle ; *b*, trapezius turned towards the left side ; *c*, splenius capitis, and below it splenius colli ; *d*, levator anguli scapulæ ; *e*, serratus posticus superior ; *f*, rhomboideus minor, and *g*, rhomboideus major, divided from the base of the scapula ; *h*, teres major, *i*, teres minor ; *k*, scapular head of the triceps brachii ; *l*, serratus magnus ; *n*, deep surface of the deltoid muscle turned down ; o, portion of the infraspinatus muscle attached to the great tuberosity of the humerus, the rest having been removed from the infraspinal fossa ; 1, occipital artery appearing between the trapezius and sterno-mastoid muscles ; 2, superficial cervical branch of the transverse cervical artery ; 2′, 2′, posterior scapular artery ; 2 +, its supraspinous branch ; 3, suprascapular artery ; 3′, the same after passing through the scapular notch into the infraspinous fossa, where it anastomoses with 4, the dorsal branch of the subscapular artery ; 4′, inferior scapular branch of the subscapular ; 4″, some of the descending thoracic branches of the subscapular artery ; 5, posterior circumflex artery emerging from the quadrangular space, and sending branches upwards on the shoulder-joint, round the humerus, and downwards into the deltoid muscle ; 6, anastomosis of the acromial branches of the suprascapular with the acromio-thoracic artery.

downwards with the suprascapular nerve towards the suprascapular notch. At this point the nerve usually passes beneath the ligament stretched across the notch, while the artery more frequently turns over it to enter the supra-spinous fossa, where, lying close to the bone, it gives off branches which ramify in the fossa beneath the supraspinatus muscle, and sends a small communicating branch into the subscapular fossa, and is itself continued down into the infraspinous fossa.

Branches.—(*a*) *Muscular* branches are given by the suprascapular artery to the sterno-mastoid and other neighbouring muscles.

(*b*) The *supra-acromial* branch passes obliquely forwards through the attachment of the trapezius to reach the cutaneous surface of the acromion, on which it ramifies, anastomosing with offsets from the acromial thoracic artery.

(*c*) A small *subscapular* branch, given off as the artery passes over the notch, anastomoses with the posterior scapular and subscapular arteries in the subscapular fossa and substance of the subscapularis muscle.

(*d*) An *infraspinous* branch is continued from the suprascapular artery, and descending close upon the neck of the scapula, between the glenoid cavity and the spine of that bone, joins with the dorsal branch of the subscapular artery.

(*e*) Branches enter the bone and shoulder joint.

Peculiarities.—The suprascapular artery has in some cases been observed to spring directly from the subclavian, or to arise from that vessel by a common trunk with the transverse cervical, or more rarely with the internal mammary. It has also been found to proceed from the axillary artery, and from the subscapular branch of that vessel.

3. The Transverse Cervical Artery, the third branch of the thyroid axis, passes outwards a short distance above the clavicle, and therefore higher than the suprascapular artery. It crosses over the scaleni muscles and the brachial plexus, sometimes passing between the nerves of the latter, and is crossed by the omo-hyoid muscle. Beneath the anterior margin of the trapezius, and near the outer edge of the levator anguli scapulæ, it divides into two branches, the superficial cervical and the posterior scapular.

The *superficial cervical* artery ascends beneath the anterior border of the trapezius, and distributes branches to that muscle, the levator anguli scapulæ, and sterno-mastoid muscles, as well as to the cervical glands and the integuments in the intervals between those muscles. When the posterior scapular arises separately from the subclavian, the name superficial cervical may be given to the whole remaining part of the transverse cervical artery.

The *posterior scapular* artery, whether arising from the transverse cervical artery or directly from the subclavian, passes backwards to the upper angle of the scapula, under cover of the levator anguli scapulæ, and then changing its direction, runs downwards beneath the rhomboidei muscles, as far as the inferior angle of that bone. It anastomoses freely on both surfaces of the scapula with the divisions of the suprascapular and subscapular arteries; and supplies branches to the rhomboidei, serratus magnus, and latissimus dorsi muscles, communicating at the same time with the posterior muscular branches of some of the intercostal arteries.

Peculiarities.—Not only does the transverse cervical branch of the thyroid axis present the variation of being nearly as often the superficial cervical alone as of comprising also the posterior scapular artery, but it occasionally happens that the vessel derived from the thyroid axis is very small, and represents only in part the superficial cervical artery; whilst a large vessel arising from the third part of the subclavian divides near the levator anguli scapulæ into two branches, of which one ascends and

represents the remaining and larger portion of the superficial cervical artery, while the other forms the posterior scapular.

The transverse cervical artery is sometimes derived directly from the subclavian, beneath or even beyond the scalenus anticus muscle. The transverse cervical sometimes gives off the ascending cervical artery.

When the *superficial cervical* is separated from the posterior scapular, it sometimes arises from other sources than the thyroid axis, as from the suprascapular or the subclavian artery.

III. INTERNAL MAMMARY ARTERY.

The internal mammary artery, remarkable for its length and the number of its branches, arises from the under side of the subclavian, opposite the thyroid axis. It runs forwards and downwards behind the clavicle to the inner surface of the cartilage of the first rib, lying between this and the sac of the pleura : from this point it inclines a little inwards, and then descends vertically behind the costal cartilages, a short distance from the border of the sternum, as far as to the interval between the sixth and seventh cartilages, where it ends by dividing into two branches. One of the branches into which the artery divides, musculo-phrenic, inclines outwards along the margin of the thorax ; while the other, under the names of abdominal or superior epigastric, continues onwards to the abdomen in the original direction of the trunk.

Covered at its origin by the internal jugular vein, like the other large branches of the subclavian artery, the internal mammary soon passes behind the subclavian vein, and is crossed in front by the phrenic nerve which lies between the vein and the artery. In the chest it has the costal cartilages and the internal intercostal muscles in front, and lies at first upon the pleura ; but lower down it is separated from the pleura by the triangularis sterni muscle. This artery has two companion veins, which are united into a single trunk at the upper part of the chest.

Branches.—The branches of this artery are numerous, and are distributed chiefly to the walls of the chest and abdomen.

(*a*) The *superior phrenic* or *comes nervi phrenici*, a very slender but long branch, arises high in the chest, and descends with the phrenic nerve, between the pleura and the pericardium, to the diaphragm, in which it is distributed, anastomosing with offsets from the musculo-phrenic and with the inferior phrenic arteries from the abdominal aorta.

(*b*) The *mediastinal* or *thymic* branches, of very small size, ramify in the loose connective tissue of the mediastinal space, and supply the remains of the thymus body, which, when in full development, receives its principal branches from the internal mammary artery. *Pericardiac* branches are given off directly to the upper part of the pericardium, the lower part of which receives some from the musculo-phrenic division. Branches named *sternal* are also supplied to the triangularis sterni muscle, and to both surfaces of the sternum.

(*c*) The *anterior intercostal arteries*, two in each space, arise from the internal mammary, either separately, or by a trunk common to the two, which soon divides. The arteries pass outwards, at first between the pleura and the internal intercostal muscles, and afterwards between the two layers of intercostals; they lie, one near the upper and one near the lower rib, in each of the upper five or six intercostal spaces, and inosculate with the corresponding intercostal branches derived from the aortic intercostals. These branches supply the intercostal and pectoral muscles, and give some offsets to the mamma and integument.

(*d*) The *anterior* or *perforating* branches pass forwards from the internal mammary artery through from four to six intercostal spaces, and turning outwards ramify partly in the pectoralis major, and partly in the integument on the front of the chest.

Those placed nearest to the mammary gland supply that organ, and in the female they are of comparatively large size, especially during lactation. Some offsets ramify on the sternum.

Fig. 265.

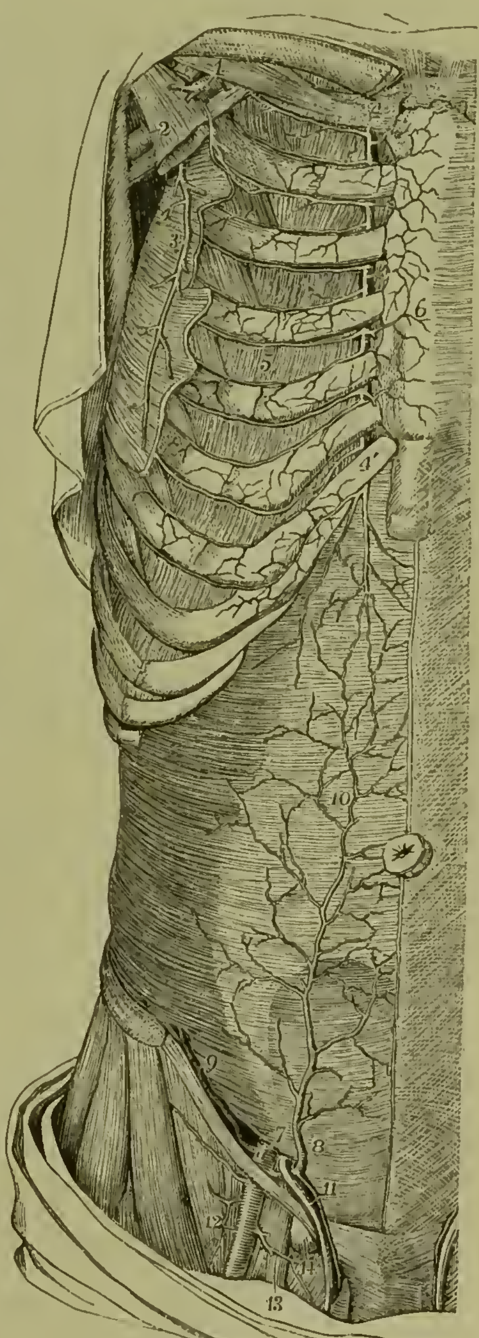


Fig. 265—Dissection of the right side of the anterior Thoracic and Abdominal Wall, to show the Anastomoses of the Internal Mammary, Intercostal, and Epigastric Vessels (slightly altered from Tiedemann). $\frac{1}{4}$

The pectoral part of the serratus magnus, the external and internal oblique, and the rectus abdominis muscles, have been removed; 1, upon the subclavius muscle, points to the first part of the axillary artery above the pectoralis minor muscle, giving rise to the acromio-thoracic artery, which is cut short; 2, upon the pectoralis minor, points to the lower part of the axillary artery and vein; 3, the long thoracic artery; 4, on the cartilage of the first rib, marks the upper part of the internal mammary artery; 4′, the lower part of the same artery giving its abdominal branch behind the cartilage of the seventh rib; 5, in the fourth intercostal space, marks the anastomosis of the internal mammary and intercostal arteries; 6, anterior branches of the internal mammary artery ramifying over the front of the sternum; 7, on the transversalis muscle immediately above the internal inguinal aperture, points to the last part of the external iliac artery, from which are seen rising, 8, the deep epigastric artery, and 9, the deep circumflex iliac; 10, the anastomosis of the epigastric with the abdominal branch of the internal mammary artery; 11, the spermatic cord and spermatic twig of the epigastric artery; 12, the femoral artery giving small twigs to the groin and the superficial pudic vessels; 13, the femoral vein; 14, a lymphatic gland closing the femoral ring.

(*e*) The *musculo-phrenic* artery, the outer of the two branches into which the internal mammary artery divides, inclines downwards and outwards behind the cartilages of the false ribs, perforating the attachment of the diaphragm at the eighth or ninth rib, and becoming gradually reduced in size as it reaches the last intercostal space. It gives branches backwards into the diaphragm; others, which pass outwards to form the anterior intercostals of each space, and are disposed precisely like those which are derived higher up from the main internal mammary; and some which descend into the abdominal muscles.

(*f*) The *abdominal branch* or *superior epigastric artery* of the internal mammary, descending into the wall of the abdomen, lies behind the rectus, between the muscle and its sheath; and afterwards, entering the muscle, terminates in its substance, at

the same time anastomosing with the epigastric artery. It also supplies twigs to the broad muscles of the belly, to the skin, and to the diaphragm; and one runs forwards upon the side and front of the xiphoid cartilage, where it anastomoses with that of the opposite side.

Peculiarities.—The internal mammary is occasionally found connected at its origin with the thyroid axis, or with the scapular arteries—these being detached from the thyroid. It occasionally springs from the second or third part of the subclavian artery (the latter being the more frequent position of the two). In very rare instances it has been found arising from the axillary, the innominate, or the aorta.

An unusual branch, of considerable size, occasionally comes off from it, and passes downwards and outwards, crossing several of the ribs, on their inner surface, in contact with the pleura. The internal mammary artery may likewise furnish a bronchial branch.

IV. SUPERIOR INTERCOSTAL AND DEEP CERVICAL ARTERIES.

The superior intercostal artery generally arises from the upper and back part of the subclavian, behind the anterior scalenus muscle on the right side, and immediately at the inner side of the muscle on the left side. Taking its course backwards, it speedily gives off the deep cervical branch (profunda cervicis), and bending backwards and downwards in front of the neck of the first rib, ends in one or two intercostal spaces: on the right side it more frequently descends into the second space than on the left side. On the neck of the first rib, the artery is situated on the outer side of the first dorsal ganglion of the sympathetic nerve.

Branches.—Besides giving off the deep cervical artery, the superior intercostal gives branches to the first and second intercostal spaces. The branch to the first space is similar in course and distribution to the aortic intercostals: that to the second space usually joins with one from the first aortic intercostal. A small offset is likewise sent backwards, through the first space, to the posterior spinal muscles, and also a small one through the corresponding intervertebral foramen to the spinal cord and its membranes.

Peculiarities.—*Origin.*—The superior intercostal artery has been found, in a few instances, to proceed from the vertebral artery or from the thyroid axis.

Course.—It has been observed to pass between the necks of one or two ribs and the corresponding transverse processes of the dorsal vertebræ; and a case has been recorded in which, after arising from the vertebral artery, it descended through the intertransverse foramen of the last cervical vertebra, and then continued, as in the instances just mentioned, between the necks of the ribs and the contiguous transverse processes of the vertebræ of the back. (Quain on the Arteries, plate 22, fig. 5.) The intercostal artery is sometimes, though very rarely, wanting.

The deep cervical artery, often described as a separate branch of the subclavian artery, arises in most cases from the superior intercostal. Resembling the posterior branch of an aortic intercostal artery, it generally passes backwards in the interval between the transverse process of the last cervical vertebra and the first rib, to reach the posterior aspect of the neck. Here it ascends in the interval between the transverse and spinous processes, as high as the second vertebra, under cover of the complexus muscle, between this and the semi-spinalis colli. Some of the branches communicate with those given outwards by the vertebral artery, whilst others ascend to anastomose with the cervical branch of the occipital artery.

Peculiarities.—*Origin.*—The deep cervical artery sometimes arises from the subclavian, and more rarely from the posterior scapular. It is not unfrequently supplemented by a branch turning backwards from the ascending cervical artery beneath the transverse process of the third cervical vertebra, or by another branch from the superior intercostal, or, in some instances, by a twig from the posterior scapular or inferior thyroid arteries.

Course.—This artery occasionally passes back between the sixth and seventh cervical vertebræ, and sometimes between the first and second dorsal, or even below the second. It has been seen to pass between the first rib and the transverse process which supports it.

AXILLARY ARTERY.

The *axillary artery*, that part of the artery of the upper limb which intervenes between the subclavian and the brachial portions, extends from the outer border of the first rib to the lower margin of the tendons of the latissimus dorsi and teres major muscles. In this course it passes through the axilla, and its direction varies with the position of the limb, being curved downwards, or upwards, or being straight, according as the arm hangs by the side, or is elevated, or extended.

In front, the axillary artery is covered by the pectoralis major muscle, behind which it is crossed by the pectoralis minor. It may be conveniently divided into three parts: the first part lying internal to the pectoralis minor muscle, and resting on the thoracic wall; the second part behind that muscle, and passing from the thorax towards the shoulder; the third part beyond the muscle, and resting on the humerus.

In the *first* part of its course the vessel is in contact with the serratus magnus muscle on its inner side, and is covered by the costo-coracoid membrane, which, attached above to the clavicle, is continued below into a common sheath investing the artery and vein, and completed behind by a prolongation of the deep cervical fascia. In this part of its course the artery is placed with the trunks of the brachial plexus above and behind it, and the axillary vein in front of it and somewhat nearer the thorax: it is also crossed by the cephalic and acromio-thoracic veins as they dip down to terminate in the axillary vein.

In the *second* part of its course, behind the pectoralis minor, the axillary artery is completely surrounded by the trunks of the brachial plexus, and it is crossed in front by one of the roots of the median nerve: the vein is on the thoracic side of the artery, separated from it by nerves.

In the *third* part of its course, beyond the pectoralis minor, the axillary artery rests on the subscapular muscle and the insertions of the latissimus dorsi and teres major, while to the outer side is the coraco-brachialis muscle. The axillary vein is still on the thoracic side, but sometimes the venæ comites, by whose union it is formed, are continued up to this level, one on each side of the artery. The main branches resulting from the division of the brachial plexus of nerves are disposed behind and on each side of this part of the artery, as follows, viz., behind it, the circumflex and musculo-spiral; to its inner side, the ulnar and the two internal cutaneous; to the outer side, the external cutaneous and median. The external cutaneous and the circumflex nerves leave the artery in the axilla, and at the lower part of the axilla the median nerve is often before the vessel; in an operation, that nerve might serve as a guide to the position of the artery, for it could be distinguished from the other large nerves (ulnar and musculo-spiral) by the circumstance of its being the nearest to the pectoral muscle. Beyond the border of the pectoralis major, the artery is covered only by the skin and fascia on the inner side; and here the flow of blood may be controlled by pressure of the finger directed outwards against the humerus.

Branches.—The branches of the axillary artery consist of the *external thoracic* branches furnished to the muscles of the chest, the *subscapular*

Fig. 266.

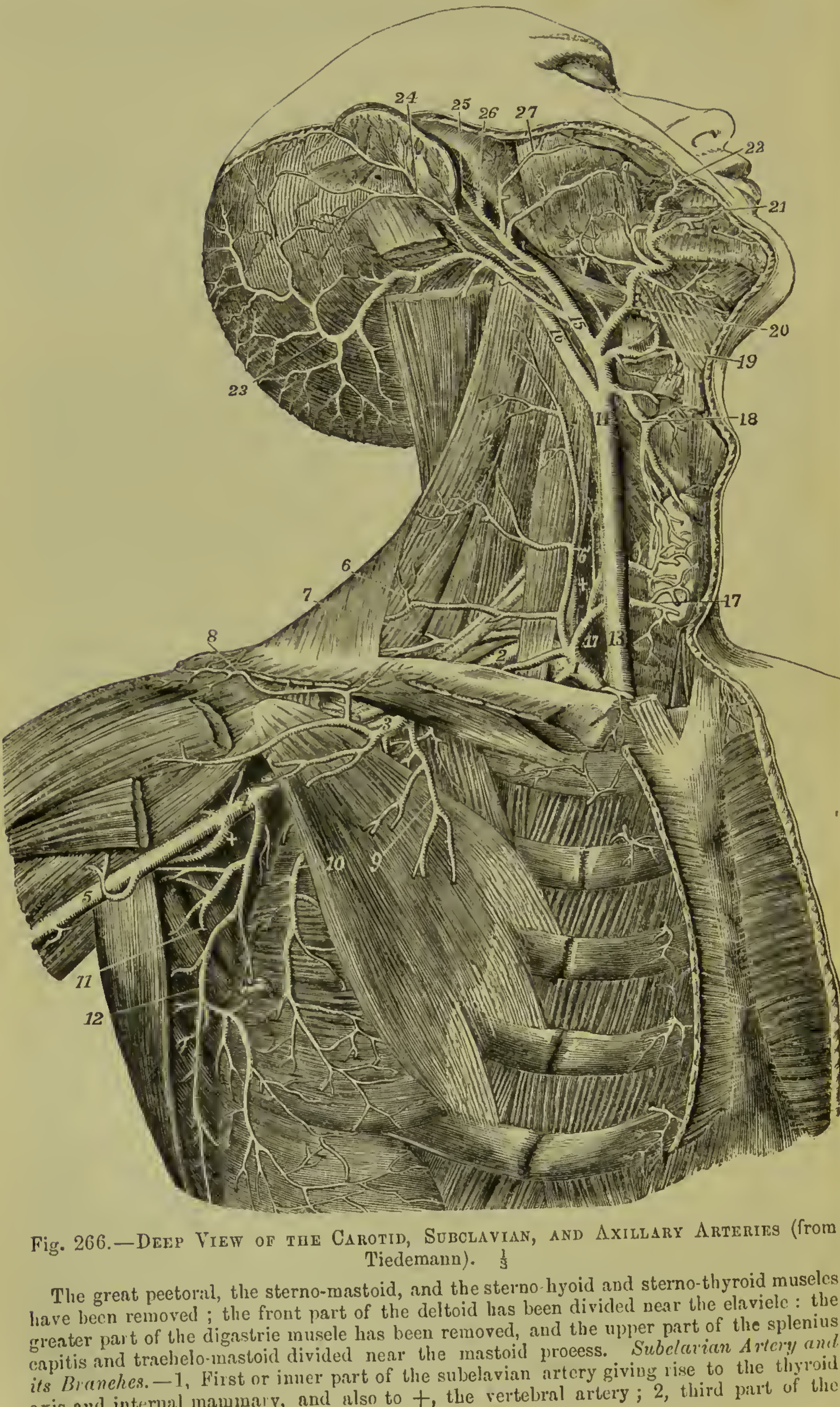


Fig. 266.—Deep View of the Carotid, Subclavian, and Axillary Arteries (from Tiedemann). $\frac{1}{3}$

The great pectoral, the sterno-mastoid, and the sterno-hyoid and sterno-thyroid muscles have been removed ; the front part of the deltoid has been divided near the clavicle : the greater part of the digastric muscle has been removed, and the upper part of the splenius capitis and trachelo-mastoid divided near the mastoid process. *Subclavian Artery and its Branches.*—1, First or inner part of the subclavian artery giving rise to the thyroid axis and internal mammary, and also to +, the vertebral artery ; 2, third part of the

subclavian artery outside the scalenus anticus muscle ; 3, first part of the axillary artery giving rise to the acromial thoracic, short thoracic, &c. ; 4, third part of the axillary artery giving rise to the subscapular, circumflex, &c. ; 5, commencement of the brachial artery ; 6, transverse superficial cervical artery ; 6′, placed on the scalenus anticus muscle, marks the ascending superficial cervical branch ; 7, posterior scapular artery arising from the subclavian artery behind the scalenus anticus muscle and separate from the thyroid axis ; 8, acromial branches of the acromial thoracic ; 9, pectoral branches of the same ; 10, long thoracic artery outside the pectoralis minor muscle ; +, posterior circumflex branch of the axillary artery (the anterior circumflex is seen rising from the opposite side of the same part of the axillary trunk) ; 11, subscapular artery passing between the subscapularis and teres minor muscles to proceed to the lower angle and dorsum of the scapula ; 12, thoracic descending branch of the subscapular artery. *Carotid Artery and its Branches.*— 13, lower part, and 14, upper part of the right common carotid artery ; 15, trunk of the external carotid artery brought fully into view by the removal of the digastric muscle ; 16, trunk of the internal carotid artery ; 17, 17, the thyroid axis of the subclavian artery, and the inferior thyroid artery where it is distributed in the gland ; 18, superior thyroid artery anastomosing in the gland with the inferior thyroid ; 19, lingual artery brought into view by the removal of the lower part of the hyoglossus muscle ; 20, facial artery giving off the palatine, tonsillar, and submental ; 21, inferior labial ; 22, coronary artery ; 23, occipital artery ; 24, posterior auricular artery ; 25, superficial temporal artery ; 26, internal maxillary artery ; 27, transverse facial given off in this instance directly by the external carotid artery.

branch to the shoulder, and the *anterior* and *posterior circumflex* branches to the upper part of the arm. The branches are not constant in their number, size, or mode of origin.

EXTERNAL THORACIC BRANCHES.—These branches vary much in number ; but, after the method of Haller, four are usually described.

1. The *superior thoracic* artery (thoracica suprema), a branch of inconsiderable size, arises at a point internal to the pectoralis minor muscle, and inclines downwards and inwards across the first two intercostal spaces, anastomosing with the internal mammary and intercostal branches contained in them, and terminates between the pectoral muscles.

2. The *acromial thoracic* artery (art. thoracica humeraria), of considerable size, and by far the most constant of the thoracic branches of the axillary, arises from its forepart at the inner border of the pectoralis minor muscle, and soon divides into branches which take different directions.

(*a*) The *acromial* branches pass partly to the deltoid muscle and partly to the upper surface of the acromion, and anastomose with the suprascapular and posterior circumflex arteries.

(*b*) The *humeral* branch passes down in the interval between the pectoralis major and deltoid muscles, accompanying the cephalic vein.

(*c*) The *thoracic* branches are distributed to the serratus magnus and pectoral muscles, and anastomose with the other thoracic arteries.

(*d*) The *clavicular* branch, very small, passes inwards to the subclavius muscle.

3. The *long thoracic* or *external mammary* artery is directed downwards and inwards, along the lower border of the pectoralis minor, and is distributed to the mamma, and to the serratus and pectoral muscles, and anastomoses with the external branches of the intercostal arteries.

4. The *alar thoracic* branch is a very small vessel and not constant, being frequently wanting, and having its place supplied by branches from the thoracic and subscapular arteries. It is distributed to the lymphatic glands and the fatty tissue in the axilla.

SUBSCAPULAR ARTERY.—This branch, the largest given off by the axillary artery, arises close to the lower border of the subscapular muscle, along which it proceeds downwards and backwards, towards the inferior angle of the scapula, accompanied by the subscapular nerve ; and it terminates in

branches to the subscapularis, serratus magnus, teres major and latissimus dorsi muscles. It soon becomes considerably diminished in size, owing to its giving off a large branch to the dorsum of the scapula. Its final ramifications anastomose with one another and with the branches of the posterior scapular artery.

The *dorsal* branch (*dorsalis scapulæ*) turns back from the subscapular artery, about an inch and a half from its origin, and is sometimes larger than the continuation of the vessel. Descending along the lower border of the scapula, it passes through the interval bounded internally by the subscapularis and teres minor, externally by the latissimus dorsi and teres major, and superiorly by the long head of the triceps muscle ; and turning closely round the border of the scapula, which is frequently grooved to receive it, passes between the teres minor and the bone, and ramifies in the infraspinous fossa, where it anastomoses with the suprascapular and posterior scapular arteries.

Fig. 267.

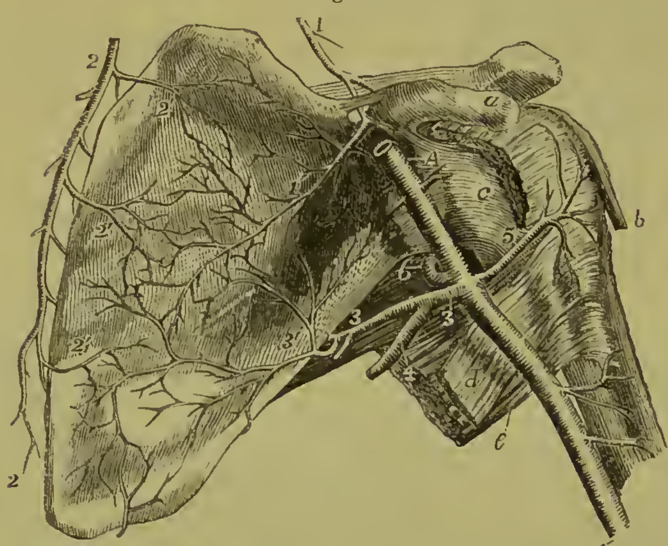


Fig. 267. — View of the Arteries which ramify and anastomose on the Ventral Surface of the Scapula, and of the Anterior Circumflex Artery (from R. Quain). 1/3

a, coracoid process; *b*, tendon of the long head of the biceps muscle emerging from the bicipital groove ; *c*, the front of the capsular ligament of the shoulder-joint; *d*, tendon of the latissimus dorsi muscle ; *e*, teres major; 1, suprascapular artery descending to the suprascapular notch, over the ligament of which the larger part of the artery passes into the supraspinous fossa ; A, A′, the axillary and brachial artery ; 1′, its subscapular branch passing through the notch and ramifying in the subscapular fossa ; 2, 2, posterior scapular artery descending parallel to the base of the scapula ; 2′, its subscapular branches ; 3, main stem of the subscapular artery at its origin from the axillary and continuation towards the dorsum of the scapula ; 3′, the branch to the ventral surface of the scapula proceeding to anastomose with the subscapular branches of the suprascapular and posterior scapular arteries ; 4, descending or thoracic branch of the subscapular artery ; 5, anterior circumflex artery ; 6, posterior circumflex passing back through the quadrilateral muscular space.

The dorsalis scapulæ gives off,—(*a*) *ventral* branches, slender vessels which ramify in the subscapular fossa between the subscapular muscle and the bone, and anastomose with twigs from the suprascapular and posterior scapular arteries ; (*b*) branches to the teres muscles, and particularly a twig which descends between their origins ; (*c*) terminal branches in the infraspinous fossa.

Circumflex Arteries.—The *posterior circumflex* artery, a considerable vessel but smaller than the subscapular, arises opposite the lower border of the subscapular muscle, below the subscapular artery, and is directed back-

wards in company with the circumflex nervo, passing through the space between the teres muscles, the humerus, and the long head of the triceps muscle, and therefore separated by the long head of the triceps from the subscapular artery. It winds round the humerus, and terminates by ramifying in the deltoid muscle and on the shoulder-joint, and by anastomosing with the anterior circumflex and suprascapular arteries, as well as with the acromial thoracic.

The *anterior circumflex*, much smaller than the posterior circumflex, arises nearly opposite to it or lower down, and from the outer side of the axillary artery. It passes from within outwards and forwards, under the inner head of the biceps and the coraco-brachialis muscle, resting on the fore part of the humerus, until it reaches the bicipital groove. There it divides into two branches, one of which ascends in the groove with the long head of the biceps, to the head of the bone and the capsule of the joint; the other continues outwards, and anastomoses with the posterior circumflex branch.

Peculiarities.—The most important peculiarity in the trunk of the axillary artery consists in its giving off a much larger branch than usual,—an arrangement which has been observed in the proportion of one out of every ten cases. In one set of cases, this large branch forms one of the arteries of the fore-arm; most frequently the radial (about 1 in 33), sometimes the ulnar (1 in 72), and, rarely, the interosseous artery (1 in 506: R. Quain). In another set of cases, the large branch gives origin to the subscapular, the two circumflex, and the two profunda arteries of the arm; but sometimes only one of the circumflex, or only one of the deep humeral arteries, arises from it. In the second class of cases the divisions of the brachial plexus of nerves surround the common trunk of the branches instead of the main vessel. This disposition may with probability be explained by supposing that the trunk of the branches is the true brachial artery, but that in early life it has become obstructed below, and that there has become developed in its place, as an apparent brachial artery for the supply of the lower portions of the limb, a vas aberrans, such as is sometimes seen arising from the brachial artery, and uniting with one of its branches.

The superior thoracic artery is so frequently given off by the acromio-thoracic, that some anatomists have described that as the normal arrangement, giving the common trunk the name of *thoracic axis*. The long thoracic artery often arises from the acromial thoracic, or is replaced by enlargement of the normal branches of that artery, and not unfrequently is given off by the subscapular.

The dorsalis scapulæ sometimes springs directly from the axillary artery.

The posterior circumflex artery is sometimes removed from the axillary to the superior profunda branch of the brachial, in which case it ascends behind the tendons of the latissimus dorsi and teres major. In another class of cases not quite so numerous, the posterior circumflex gives off one or more branches usually derived from other sources: as for example (placing them in the order of frequency), the anterior circumflex, the superior profunda, the dorsal scapular, the anterior circumflex and superior profunda together, or some other rarer combination of those vessels. The posterior circumflex is sometimes double; and so is the anterior, but more seldom.

BRACHIAL ARTERY.

The brachial or humeral artery, tho continuation of the axillary, extends from the lower border of the posterior fold of the axilla, to about a finger's breadth below the bend of the elbow, or to a point opposite the neck of the radius, where it divides into the radial and ulnar arteries. The vessel gradually inclines from the inner side to the fore part of tho limb, lying in the depression along tho inner border of the coraco-brachialis and biceps muscles; and its direction may bo marked out by a line drawn from

midway between the folds of the axilla to the middle point between the condyles of the humerus. To command the flow of blood through the artery at its upper part, pressure should be directed outwards, while over the lower end of the vessel the pressure should be made from before backwards.

The brachial artery lies beneath the integument and fascia of the arm as far as the bend of the elbow, where it sinks deeply in the interval between the pronator teres and supinator longus muscles, and is covered by the fibrous expansion given from the tendon of the biceps to the fascia of the fore-arm. It rests at first on the long head of the triceps muscle, the musculo-spiral nerve and the superior profunda artery intervening; it then inclines forwards over the insertion of the coraco-brachialis muscle, and lies thence to its termination on the brachialis anticus. At its outer side it is in apposition first with the coraco-brachialis, and afterwards and for the

Fig. 268.

Fig. 268.—Dissection of the Axilla and Inside of the Arm to show the Axillary and Brachial Vessels (from R. Quain). ¼

The greater and lesser pectoral muscles have been divided so as to expose the axillary vessels: *a*, the inserted portion of the pectoralis major; *b*, the pectoral portion; 1, 1, axillary artery; +, +, the median nerve formed by the two portions of the plexus which surround the artery; 1′, placed on a part of the sheath of the brachial vessels, and 1″, on the lower part of the biceps muscle, point to the brachial artery surrounded by its venæ comites; 2, 2, axillary vein; 3, 3, the basilic vein; the upper figure is placed on the triceps muscle, the lower on the fascia near the junction of the ulnar vein: on the basilic vein are seen the ramifications of the internal cutaneous nerve; 4, on the deltoid and 4′, on the clavicular part of the great pectoral muscle, mark the cephalic vein joining the acromio-thoracic and through it the axillary vein; 5, 5, placed on the divided portions of the pectoralis minor, point to the origin and branches of the acromio-thoracic artery; 6, placed on a group of axillary glands, indicates the alar thoracic and subscapular vessels; 7, placed on the trunk of the axillary vein, points by a line to one of the venæ comites of the brachial vein, which being joined by the other higher up passes into the axillary vein: the ulnar nerve is seen passing from below the basilic vein towards the inner condyle; near 1, placed on the coraco-brachialis muscle is seen the musculo-cutaneous nerve before it passes through that muscle; near 2, placed on the tendon of the latissimus dorsi muscle, a portion of the nerve of Wrisberg.

greater part of its length with the biceps, the inner border of one or both muscles sometimes slightly overlapping it.

Relation to Veins.—Venæ comites are in close contact with the brachial artery, short transverse branches of communication passing from one to another, so as at many points to encircle it. Superficial to the aponeurosis, the basilic vein is placed over or to the inner side of the artery in the lower half or more, or in the whole length of its course, according to the level at which the vein dips down to join the venæ comites; and at the bend of the elbow the median basilic vein crosses over the artery, the aponeurotic insertion of the biceps lying between them.

Relation to Nerves.—The median nerve descends in contact with the artery, lying on its outer side at the axilla, directly in front of it below the middle of the arm, and on the inner side at the elbow. Of the large branches of the brachial plexus which are closely connected with the axillary artery, none continue in the immediate neighbourhood of the brachial artery along the arm, except the median. The external cutaneous and circumflex separate at once from the vessel in the axilla, the musculo-spiral soon turns backwards in the musculo-spiral groove, and the internal cutaneous and ulnar nerves descend vertically on the inner side of the limb.

Fig. 269.

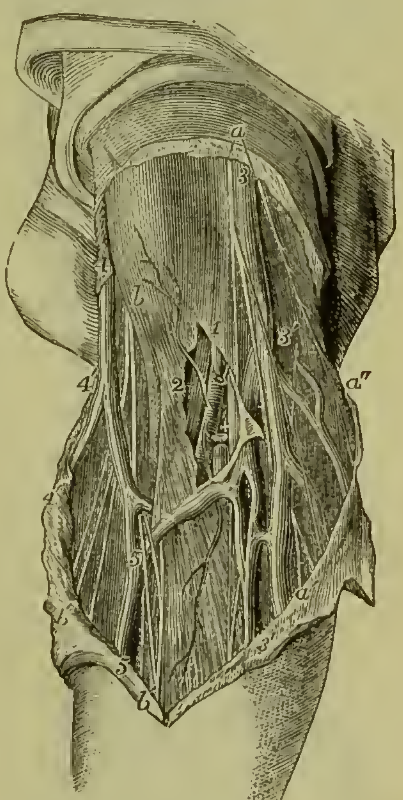


Fig. 269. — Superficial Dissection of the Blood-Vessels at the Bend of the Arm (from R. Quain). ⅓

a, two branches of the internal cutaneous nerve; *b*, placed over the biceps near its insertion and close to the external cutaneous nerve; *a′*, *a′*, the descending twigs of the same nerve; *b′*, anterior twigs of the same nerve accompanying the median vein; 1, placed on the fascia of the arm near the bend of the arm, above the place where it has been opened to show the lower part of the brachial artery with its venæ comites, of which one is entire, marked 2, and the other has been divided; +, is placed between this and the median nerve; 3, basilic vein; 3′, 3′, ulnar veins; 4, cephalic vein; 4′, radial vein; 5, 5, median vein; 3′, 5, median basilic vein; 4′, 5, median cephalic vein.

Branches.—The brachial artery gives some unnamed branches, which are directed outwards and backwards to the muscles in its immediate neighbourhood, viz., to the coraco-brachialis, biceps, and brachialis anticus. The following branches, which incline inwards, have received names, and require description:—

(*a*) The *superior profunda artery* (collateralis magna) arises from the inner and back part of the brachial, just below the border of the teres major, and inclines backwards, to reach the interval between the second and third heads of the triceps muscle. Accompanied by the musculo-spiral nerve, it winds round the back of the humerus, in the spiral groove, under

cover of the triceps, and perforating the external intermuscular septum, reaches the external and anterior aspect of the bone. There the artery lies deeply in the interval between the brachialis anticus and supinator longus muscles, considerably diminished in size by having given off several branches, and descends to the elbow, where it anastomoses with the recurrent branch of the radial artery.

Fig. 270.

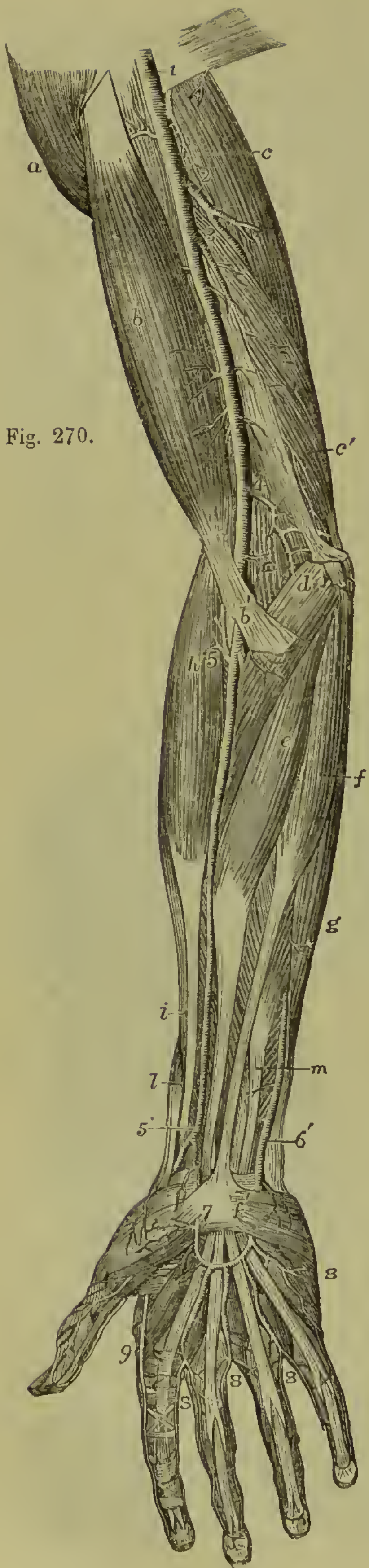


Fig. 270.—Superficial View of the Arteries of the Arm, Fore-arm, and Hand in front (from Tiedemann). ¼

a, deltoid muscle ; *b*, biceps ; *b′*, the aponeurotic insertion ; *c*, scapular head of the triceps ; *c′*, its internal head ; *d*, pronator radii teres ; *e*, flexor carpi radialis ; *f*, palmaris longus ; *f′*, its tendon spreading in the upper part of the palmar fascia, from which, on the inner side, the palmaris brevis muscle is seen rising ; *g*, flexor carpi ulnaris ; *h*, supinator radii longus ; *i*, extensor carpi radialis longior ; *l*, extensor ossis metacarpi pollicis ; *m*, flexor digitorum communis sublimis ; 1, placed on the tendon of the latissimus dorsi, the lower part of the axillary artery, continued into the brachial ; 2, superior profunda ; 3, inferior profunda ; 4, ulnar anastomotic ; 5, near the division of the brachial artery into ulnar and radial, and recurrent radial artery ; 5′, lower part of the radial artery, where it gives off the superficialis volae, and turns round the wrist ; 6′, the lower part of the ulnar artery, near the place where it passes down to form the superficial palmar arch ; 7, the superficialis volae, which joins it ; 8, 8, 8, 8, first, second, third, and fourth digital branches of the superficial arch to the inside of the little finger, adjacent sides of the 4th and 5th, 3rd and 4th, and 2nd and 3rd fingers ; 9, radialis indicis ; on the thumb are seen the two branches of the princeps pollicis artery.

The superior profunda gives off branches in its first part to the deltoid, coraco-brachialis, and triceps ; and many to the last-named muscle, whilst it is between it and the bone. In this position it also gives one long branch, which descends perpendicularly between the muscle and the bone to the back part of the elbow-joint on the outer side, where it anastomoses with the interosseous recurrent branch ; and another which anastomoses on the inner side with the ulnar recurrent and the anastomotic or the inferior profunda.

(*b*) The *inferior profunda artery* (collateralis ulnaris prima), of small size, arises from the brachial artery a little below the middle of the arm, and is

directed to the back part of the inner condyle of the humerus. Descending in company with the ulnar nerve, it pierces the intermuscular septum, then lies on the inner surface of the triceps muscle, to which it gives branches, and entering the interval between the olecranon and inner condyle, it terminates by inosculating with the posterior recurrent branch of the ulnar artery, and with the anastomotic branch of the brachial.

(c) The *nutrient artery* of the shaft of the humerus is a small branch given off by the brachial about the middle of the arm, or by one of its collateral branches. It inclines downwards, enters the oblique canal in the humerus near the insertion of the coraco-brachialis muscle, and is distributed in the interior of the bone.

(d) The *anastomotic artery* (collateralis ulnaris secunda), is a very constant branch of moderate size. Arising from the brachial artery about two inches above the bend of the arm, it is directed transversely inwards on the brachialis anticus muscle, above the inner condyle of the humerus, and, after perforating the intermuscular septum, turns outwards behind the humerus, between the bone and the triceps muscle, and forms with the superior profunda an arch across the humerus, immediately above the olecranon fossa (arcus dorsalis humeri posticus,—Haller). In front of the humerus the anastomotic artery furnishes a branch which ramifies in the pronator teres, and anastomoses with the anterior ulnar recurrent branch. Behind the inner condyle another offset joins with the posterior ulnar recurrent, and behind the humerus several branches are given to the joint and the muscle.

Peculiarities.—From their comparative frequency, and surgical interest, the peculiarities of the brachial artery, especially those which affect its trunk, deserve particular attention.

Course.—The brachial artery sometimes lies in front of the median nerve, instead of behind it.

The brachial artery has been seen, though rarely, to descend, accompanied by the median nerve, towards the inner condyle of the humerus, and regain its usual position at the bend of the elbow by passing forwards underneath a fibrous arch, from which the pronator teres in those cases arises, and which descends to the inner condyle from the occasional prominence called the supra-condyloid process, as has been previously described (p. 80). Sometimes this disposition occurs without the development of any bony prominence.

As an extremely rare condition, the artery has been found divided into two vessels near its commencement, the artery being single above and below, as also occurs with the femoral trunk.

In a very few cases the three arteries of the fore-arm, radial, ulnar, and interosseous, have arisen together from the end of the brachial trunk, at the usual distance below the elbow.

High division.—The most frequent change from the ordinary arrangement of the brachial artery is connected with its division into terminal branches.

Out of 481 examples recorded by Richard Quain from observations made, some on the right and some on the left side of the body, the vessel was found in 386 to divide at its usual position, a little below the elbow-joint. In one case only (and that complicated by another peculiarity, viz., the existence of a *vas aberrans* proceeding from the axillary to the radial), was the place of division lower than usual, being between two and three inches lower than the elbow-joint. In 64 cases the brachial artery divided *above* the usual point, at various heights upwards to the lower border of the axilla. The branch prematurely separated from the rest of the trunk in an early division, is, in the proportion of nearly three cases out of four, the radial artery; sometimes the ulnar is the branch given off; that is to say, a branch corresponding to the ulnar in its distribution below the middle of the fore-arm separates from a trunk which afterwards divides into the normal radial artery and the interosseous of the fore-arm, which last is normally derived from the ulnar artery. Rarely the interosseous of the fore-arm, or a *vas aberrans*, is the branch given off.

In all cases of the high origin of one or other of the arteries of the fore-arm the extent in which the two vessels thus formed run separately must vary according to the height at which the main artery divides. The point of division in the entire number of cases, without reference to the particular branch given off, is most frequently in the upper, less so in the lower, and least so in the middle third of the arm. But the early division of the main artery of the upper limb may, as mentioned in connection with the varieties of the axillary artery, take place within the axilla, in which case it follows that the brachial portion of the vessel is replaced, throughout its whole extent, by two separate trunks. In 94 cases out of 481 observed by R. Quain, or about one in five and one-ninth, there were two arteries instead of one in some part or in the whole of the arm.

The position of the two arteries, in these cases, is of much surgical interest. We shall here consider only their position in the arm, and subsequently trace them in their irregular course in the fore-arm. Usually they are close together, and occupy the ordinary position of the brachial artery; but there are some peculiarities in their position which require to be particularly noticed.

The *radial* artery, when thus given off in the arm, often arises from the inner side of the brachial, then runs parallel with the larger vessel (the brachial or ulnar-interosseous), and crosses over it, sometimes suddenly, opposite the bend of the elbow, still covered by the fascia. It has been found, but in a very few instances only, to perforate the fascia, and run immediately under the skin, near the bend of the elbow.

Fig. 271.

Fig. 271.—Dissection of the Right Arm, showing an example of high separation of the Radial Artery from the Brachial, and an enlarged Median Artery in the Fore-arm (from Tiedemann). 1/4

1, on the tendon of the latissimus dorsi, points to the upper part of the brachial artery; 2, the brachial artery after giving off the radial; 3, the radial rising in the upper third of the arm and descending in its usual situation in the fore-arm; 3′, its superficial volar branch; 4, the ulnar artery in its usual course, forming at 5, the superficial palmar arch, from which three of the palmar digital arteries and the princeps pollicis take origin; the radial supplying the branches to the index finger and one side of the middle finger; 6, the superior profunda branch of the brachial artery; 7, muscular branches; 8, ulnar anastomotic; 9, recurrent radial; 10, anterior interosseous giving an unusually large median branch which descends over the wrist to unite with the superficial palmar arch.

When the *ulnar* is the branch given off high from the brachial, it often inclines from the position of the brachial, at the lower part of the arm, towards the inner condyle of the humerus. This vessel generally lies beneath the fascia as it descends, and superficially to the flexor muscles.

It is occasionally placed between the integuments and the fascia; and in a single instance was found beneath the muscles. In one instance recently occurring in the dissecting-room of the Glasgow University, the ulnar artery given off from the humeral at the middle of the arm was observed to descend superficially behind the inner condyle.

The *interosseous*, after arising from the axillary or brachial artery, is commonly situated behind the main artery, and, on reaching the bend of the elbow, passes deeply between the muscles, to assume its usual position in the fore-arm.

Lastly, when the radial has arisen high in the arm, the residuary portion of the brachial (*ulnar-interosseous*) has occasionally been observed descending, accompanied by the median nerve, along the intermuscular septum towards the inner condyle of the humerus, as far as the origin of the pronator teres (which in the cases recorded was found broader than usual), whence it turned outwards under cover of the muscle, to gain the usual position at the middle of the bend of the elbow.

Fig. 272.

Fig. 272.—Aberrant Artery, separating from the brachial at the middle of the Arm, passing with the Median Nerve through the Internal Intermuscular Septum, and joining farther down the regular Ulnar (from R. Quain). $\frac{1}{4}$

a, biceps muscle; *b*, triceps; *c*, *c*, divided pronator teres; *d*, *d*, *d'*, median nerve, diverted from its usual course, and passing with the aberrant artery through the internal intermuscular septum; *e*, *e*, *e*, ulna nerve in its usual course; 1, brachial artery, giving off an aberrant artery at the middle of the arm; 2, the usual radial artery; 3, aberrant artery, with the median nerve twining round it, passing at 3′ through the internal intermuscular septum; 3″, the same farther down, and communicating at 4′ with the first part of the normal ulnar artery, 4, given off from the brachial.

The two arteries taking the place of the brachial are in some instances connected near the bend of the arm by an intervening trunk, which proceeds from the larger (or ulnar-interosseous) artery to the radial or the radial recurrent, and varies somewhat in its size, form, and course. More rarely the two unusual arteries are actually *re-united*.

The *aberrant arteries*, "vasa aberrantia," alluded to in the preceding statement, are long slender vessels, which arise either from the brachial or the axillary artery, and end by joining one of the arteries of the fore-arm, or one of their branches. In eight cases out of nine, observed by Quain, this unusual vessel joined the radial; in the remaining case it joined the radial recurrent, which arose irregularly from the ulnar artery. Monro and Meckel have each seen one case in which the aberrant vessel joined the ulnar. This peculiarity may be regarded, perhaps, as an approach to that condition in which there is division of the brachial artery and subsequent connection of its two parts by an intervening branch.

State of the arteries in both limbs.—In most cases of the high division of the brachial arteries the condition of the vessels is not the same in the right and left arms. In 61 bodies in which the high division existed, it occurred only on one side in 43; on both sides, in different positions, in 13; and on both sides, in the same position, in the remaining 5.

Branches.—It has been already mentioned (p. 381) that the *superior profunda*

Fig. 273.

may give origin to the posterior circumflex artery, and that its own origin is sometimes transferred to a branch arising from the axillary artery.

The *inferior profunda* is likewise occasionally absent, and on that account has not been recognised by some anatomists as a regular branch of the brachial artery.

The *anastomotic* artery is sometimes much reduced in size, and in that case the inferior profunda takes its place behind the humerus.

Fig. 273.—Deep Anterior View of the Arteries of the Arm, Fore-arm, and Hand (from Tiedemann). $\frac{1}{4}$

The biceps brachii, the pronator teres and muscles rising from the inner condyle, the supinator longus, the lower part of the flexor longus pollicis and flexor profundus digitorum, the anterior annular ligament of the carpus and the muscles of the ball of the thumb have been removed; *n*, pronator quadratus muscle; 1, lower part of the axillary artery continued into the brachial; 2, superior profunda branch; 3, inferior profunda; 4, ulnar anastomotic; 5, upper part of the radial artery and radial recurrent; 5′, lower part of the radial artery giving off the superficialis volæ branch; 5″, the radial artery emerging from between the heads of the abductor indicis muscle; 6, 6, the upper part of the ulnar artery with the anterior and posterior ulnar recurrent branches; 6′, the ulnar artery approaching the wrist and descending into the superficial palmar arch which has been cut short; 6″, the deep branch of the ulnar artery uniting with the deep palmar arch; 7 (marked only on one), three interosseous branches from the deep palmar arch joining the palmar digital arteries 8, 8, 8, which have been cut away from their origin from the superficial arch to near their division into the collateral digital arteries; the ulnar collateral of the little finger is represented as rising in this instance from the deep ulnar artery; 9, placed between the princeps pollicis and radialis indicis branches of the radial artery; 10, lower part of the anterior interosseous artery passing behind the pronator quadratus muscle; 11, anastomosis of the anterior carpal branches of the radial and ulnar arteries with recurrent branches from the deep palmar arch.

ULNAR ARTERY.

The ulnar artery, the larger of the two vessels into which the brachial divides, extends along the inner side of the fore-arm into the palm of the hand, where, joining a branch of the radial, opposite the muscles of the thumb, it forms the superficial palmar arch. In this course it inclines at first downwards and inwards, describing a slight curve, the convexity of which is directed inwards, and passes under cover of

the superficial muscles arising from the inner condyle of the humerus, viz., the pronator teres, flexor carpi radialis, palmaris longus, and flexor sublimis, until it reaches the flexor carpi ulnaris near the junction of the upper with the middle third of the fore-arm; at this point the artery comes into contact with the ulnar nerve, which was previously separated from it by a considerable interval, and changing its direction, descends vertically with the nerve towards the inner border of the palm of the hand. Descending along the radial border of the tendon of the flexor ulnaris muscle, the ulnar artery reaches the outer or radial side of the pisiform bone, where, still accompanied by the nerve, it passes over the cutaneous surface of the anterior annular ligament of the wrist into the palm of the hand. Its disposition in the hand will be separately described.

In the first half of its course through the fore-arm, the artery is deep-seated, being covered by the muscles arising from the inner condyle of the humerus which have been already enumerated. About the middle of the fore-arm it is overlapped by the fleshy part of the flexor carpi ulnaris; but below that, it becomes more superficial, being overlaid by the tendon of the muscle, and covered by the skin, the fascia of the fore-arm, and a thin layer of membrane by which the vessel is bound down to the muscle beneath. At first the ulnar artery lies on the insertion of the brachialis anticus into the coronoid process of the ulna; then on the flexor profundus in the rest of the fore-arm, and lastly, on the annular ligament of the carpus. Below the point at which it emerges from under the flexor carpi ulnaris (or a little below the middle of the fore-arm), the tendon of that muscle is on its inner or ulnar side.

Relation to Nerves.—The *median nerve* lies immediately on the inner side of the ulnar artery at its origin, but being directed down the middle of the fore-arm it soon passes over the vessel, separated from it at the point of crossing by the deep head of the pronator teres muscle. As the *ulnar nerve* descends behind the inner condyle of the humerus, it is removed from the ulnar artery by a considerable interval at the upper part of the fore-arm; but as the vessel inclines inwards, it approaches the nerve, and is accompanied by it in the lower half of its course—the nerve lying close to its inner side. A small branch of the ulnar nerve descends upon the lower part of the vessel.

Relation to Veins.—Two veins (venæ comites) accompany the ulnar artery, and are frequently united by branches crossing it.

Branches.—The ulnar artery gives off in the fore-arm the anterior and posterior recurrent, the interosseous, and several muscular branches. At the wrist it gives off the anterior and posterior carpal branches.

Recurrent Branches.—The *anterior ulnar recurrent* artery, a small branch, arches inwards and upwards from the upper part of the ulnar artery, running on the brachialis anticus muscle, and covered by the pronator teres, both which muscles it partly supplies. On reaching the front of the inner condyle, it anastomoses with the inferior profunda and anastomotic arteries, derived from the brachial.

The *posterior ulnar recurrent*, larger than the preceding, comes off lower down; but not unfrequently the two vessels arise by a short common trunk. The posterior recurrent runs inwards and backwards beneath the flexor sublimis, and then ascends behind the inner condyle. In the interval between that process and the olecranon it lies beneath the flexor carpi ulnaris, and passing between the heads of that muscle along the ulnar nerve, supplies branches to the muscles, to the elbow joint, and to the nerve itself. This

branch communicates with the inferior profunda, the anastomotic, and, over the olecranon, likewise with the interosseous recurrent.

Fig. 274.

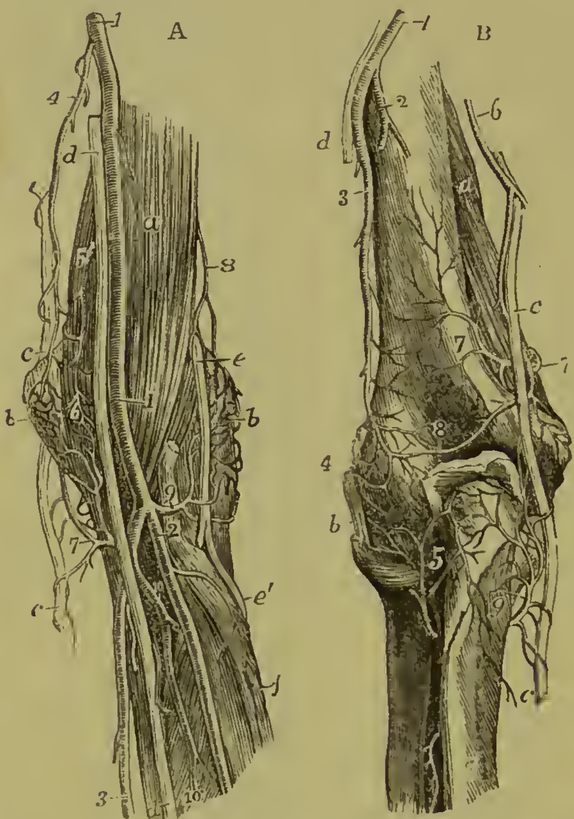


Fig. 274.—View of the Anastomoses of Arteries near the Elbow-Joint: A, from before; B, from behind (from R. Quain). $\frac{1}{4}$

A. *a*, brachialis anticus muscle; *b*, external condyloid eminence covered by the supinator radii brevis and the anastomoses of the superior profunda and radial recurrent arteries; *c* ulnar nerve; *d*, median nerve; *e*, musculo-spiral nerve; *e'*, its posterior interosseous branch: its radial branch is cut; *f*, oblique line of the radius; 1, brachial artery; 2, radial artery; 3, ulnar artery; 4, inferior profunda; 5, anastomotic; 6, anterior ulnar recurrent anostomosing with the anterior descendiug branches of the auastomotic; 7, posterior ulnar recurrent passing up behind the inner condyloid emineuce to anastomose with the inferior profunda and posterior branch of the anastomotic; 8, spiral branch of the superior profunda; 9, placed on the tendon of the biceps muscle, points to the radial recurrent artery; 10, 10, interosseous artery and its anterior branch.

B. *a*, a part of the brachialis anticus muscle; *b*, external lateral ligament of the elbow-joint; *c*, ulnar nerve; *d*, a small part of the musculo-spiral nerve; 1, superior profunda artery; 2, its branch to the triceps muscle; 3, its spiral branch to the outer condyle; 4, its anastomosis with the recurrent radial artery; 5, recurrent of the posterior interosseous artery, passing up to anastomose with the preceding and with the anastomotic behind the joint; 6, inferior profunda; 7, posterior brauch of the anastomotic artery; 8, anastomosis of the anastomotic and inferior profuuda with the superior profunda and the posterior interosseous recurrent; 9, posterior ulnar recurrent artery passing up in the groove of the ulnar nerve to anastomose with the inferior profuuda and anastomotic.

Interosseous Artery.—The interosseous or *common interosseous* artery, the next, and the largest branch of the ulnar, is a trunk of considerable size, about an inch in length, which arises below the bicipital tuberosity of the radius, beneath the flexor sublimis, and passes backwards to reach the upper border of the interosseous ligament, where it divides into the *anterior* and *posterior* interosseous arteries.

The *anterior interosseous* descends upon the anterior surface of the interosseous ligament, accompanied by the interosseous branch of the median nerve and venæ comites, and overlapped by the contiguous borders of the flexor profundus digitorum and flexor longus pollicis muscles. It continues its course directly downwards as far as the upper border of the pronator quadratus muscle, then pierces the interosseous ligament, and descends to the back of the carpus.

The anterior interosseous artery gives off the following branches :—

(a) The artery of the median nerve, or the *median artery*, a long slender branch, which accompanies the median nerve and sends offsets into its substance. This artery is sometimes much enlarged, and in that case it presents several peculiarities to be hereafter noticed.

(b) *Muscular* branches to the flexor profundus, flexor longus pollicis, and pronator quadratus muscles.

(c) The *nutrient* arteries of the shafts of the radius and ulna, which diverging from one another, enter the oblique foramina in those bones to be distributed to the medullary membrane in their interior.

(d) An anterior inosculating branch, given off before the artery pierces the interosseous membrane, and descending beneath the pronator quadratus muscle to anastomose with the anterior carpal arteries.

(e) Terminal twigs inosculating with the posterior carpal arteries.

The *posterior interosseous* artery passes backwards through the interval left between the oblique ligament and the upper border of the interosseous ligament, and continuing its course downwards along the fore-arm, covered by the superficial layer of extensor muscles, gives branches to them and the deep-seated muscles, and reaches the carpus considerably diminished in size.

In addition to muscular branches, it gives off the following :—

(a) The *posterior interosseous recurrent*, which passes directly upwards, covered by the anconeus, to reach the interval between the olecranon and external condyle ; at which place it divides into several offsets which anastomose with the superior profunda and the posterior ulnar recurrent.

(b) *Terminal* branches, which anastomose with the posterior or terminal branch of the anterior interosseous artery, and with the carpal branches of the radial and ulnar arteries.

Muscular Branches of the ulnar artery are distributed to the muscles in the course of the vessel along the fore-arm : some of these perforate the interosseous ligament to reach the extensor muscles.

Carpal Branches.—The *posterior ulnar carpal* branch, of variable size, arises a little above the pisiform bone, and winding back under the tendon of the flexor carpi ulnaris, reaches the dorsal surface of the carpus beneath the extensor tendons.

Its branches are the following :—

(a) A branch anastomoses with the posterior carpal artery derived from the radial, so as to form the *posterior carpal arch*, and from this arch are derived the *second* and *third dorsal interosseous arteries*, which descend on the spaces between the third and fourth and the fourth and fifth metacarpal bones, and are reinforced at the upper ends of those spaces by anastomoses with the posterior perforating branches of the deep palmar arch.

(b) A branch runs along the metacarpal bone of the little finger. Sometimes this *metacarpal branch* arises as a separate vessel, the posterior carpal being then very small.

The *anterior ulnar carpal* branch is a very small artery, which runs on the anterior surface of the carpus beneath the flexor profundus, anastomoses with a similar offset from the radial artery, and supplies the carpal bones and articulations.

Peculiarities.—*Origin.*—In the whole number of cases observed by Richard Quain, the ulnar artery was found to deviate from its usual mode of *origin*, nearly in the proportion of one in thirteen. The brachial artery was, more frequently than the axillary, the source from which it sprang ; indeed, the examples of its origin from the main trunk at different parts appeared to decrease in number in proportion as the

place of origin was higher up the artery. (See on this subject the description of the peculiarities of the axillary and brachial arteries, pp. 381 and 385.)

Fig. 275.

Fig. 275.—Abnormal Superficial Ulnar Artery rising higher than usual from the Brachial. ¼

This figure has been taken from a preparation in A. Thomson's collection; the drawing being planned after that of a similar case represented by R. Quain. Tab. xxxvi. Fig. 1.

a, biceps muscle covered by the deep brachial fascia; *b*, the same fascia in the fore-arm, which has been opened in a considerable extent to show the radial artery subjacent to it; *c*, median nerve; *d*, ulnar nerve; 1, on the biceps muscle, points to the brachial artery after having given off an ulnar artery higher up, and dividing at 1′, into the radial artery and a deep vessel corresponding to the interosseous and a part of the usual ulnar; 2, on the supinator longus muscle, points to the radial artery; 3, 3, artery which is given off by the brachial in the arm, and which descending upon the fascia takes the place of the ulnar at the wrist; 3′, the same continued into the superficial palmar arch, giving off digital branches nearly in the usual manner, and joined by a branch from the radial, 4, the superficial volar; 5, digital branches; towards the thumb a communication of the superficial arch with the princeps pollicis exists.

Course.—The *position* of the ulnar artery in the fore-arm is more frequently altered than that of the radial. When it arises in the usual way, the course of this artery is not often changed; but it has been seen to descend apart from the tendon of the flexor carpi ulnaris, instead of being close to its radial border.

In cases of high origin, it almost invariably descends over the muscles arising from the inner condyle of the humerus, only one exception to this rule having been met with. (R. Quain, plate 36, fig. 2.)

Most commonly it is covered by the fascia of the fore-arm; but cases also occur in which the vessel rests on the fascia, and either continues in that position or becomes subaponeurotic lower down, while the vessel thus disposed is distributed after the manner of the normal ulnar artery. The vessel from which the high ulnar separates is afterwards divided into the radial artery and the interosseous, the last of which is usually derived from the ulnar; it appears therefore probable that the abnormal arrangement results from early obstruction of the ulnar artery below the origin of the interosseous, and the development of a superficial vas aberrans, which unites the portion of vessel below the obstruction with the axillary or brachial trunk. The interosseous artery in such cases of abnormality thus comprises not only the ordinary interosseous branch, but likewise the portion of ulnar artery above the obstruction; and, in accordance with this view, we find that the recurrent branches are derived from it.

As to *size*, the ulnar artery presents some peculiarities which, being accompanied by deviations of an opposite and compensating character in the radial artery, will be noticed with that vessel.

Branches.—The *anterior* and *posterior ulnar recurrent branches* frequently arise by a common trunk. One or both have been seen to arise from the brachial artery.

The *anterior* and *posterior interosseous* arteries are occasionally given separately from the ulnar. The common interosseous trunk has been found to arise above its ordinary situation, taking origin from the brachial, and even (but more rarely) from the axillary artery. The anterior interosseous presents some striking varieties of excess in its branches, usually connected with a deficiency in the radial or ulnar arteries: the most important of these is enlargement of the median branch.

Median artery.—The branch accompanying the median nerve is sometimes much enlarged, and in such cases may be regarded as a reinforcing vessel. It is generally a branch of the anterior interosseous, but sometimes of the ulnar; and more rarely a median branch has been met with descending from the brachial artery. Accompanying the median nerve beneath the annular ligament into the palm of the hand, the median artery ends most frequently by joining the superficial palmar arch, sometimes by forming digital branches, in other cases by joining digital branches given from other sources.

SUPERFICIAL PALMAR ARCH.

The superficial palmar arch or artery (arcus superficialis volæ,—Haller) is the continuation of the ulnar artery into the hand. Changing its course near the lower border of the annular ligament, this artery turns obliquely outwards across the palm of the hand towards the middle of the muscles of the thumb, where it terminates by inosculating with a small branch of the radial artery—the superficial volar, generally passing through among the muscles of the thumb. In its course across the hand, the palmar artery describes a curve, having its convexity directed towards the fingers, and extending downwards somewhat lower than a line on a level with the phalangeal articulation of the thumb.

The superficial palmar artery rests at its commencement on the annular ligament of the wrist, and slightly on the short muscles of the little finger; then on the tendons of the superficial flexor of the fingers, and the divisions of the median and ulnar nerves, the latter nerve accompanying the vessel for a short distance. It is covered towards the ulnar border of the hand by the palmaris brevis, and afterwards by the palmar fascia and the integument.

Branches.—The branches given off by the superficial palmar arch, which are generally numerous, are as follow :—

(*a*) The *deep* or *communicating* branch arises from the ulnar artery at the commencement of the palmar arch a little beyond the pisiform bone, sinks deeply between the flexor brevis and the abductor of the little finger, and inosculates with the palmar termination of the radial artery, thereby completing the deep palmar arch.

(*b*) Small branches, some following a retrograde course towards the annular ligament, are given off to the parts in the palm of the hand from the upper or concave side of the palmar arch.

(*c*) The *digital* branches, usually four in number, proceed downwards from the convexity of the palmar arch to supply both sides of the three inner fingers, and the ulnar side of the fore finger. The *first digital* branch inclines inwards to the ulnar border of the hand, and after giving minute offsets to the muscles of the little finger, runs along the inner margin of its phalanges. The *second* runs along the fourth metacarpal space, and at the root of the fingers divides into two branches, which proceed along the contiguous borders of the ring finger and little finger. The *third* is similarly distributed to the ring finger and middle finger; and the *fourth* to the

latter and the index finger. The thumb and the radial side of the index finger are supplied from the radial artery.

Fig. 276.

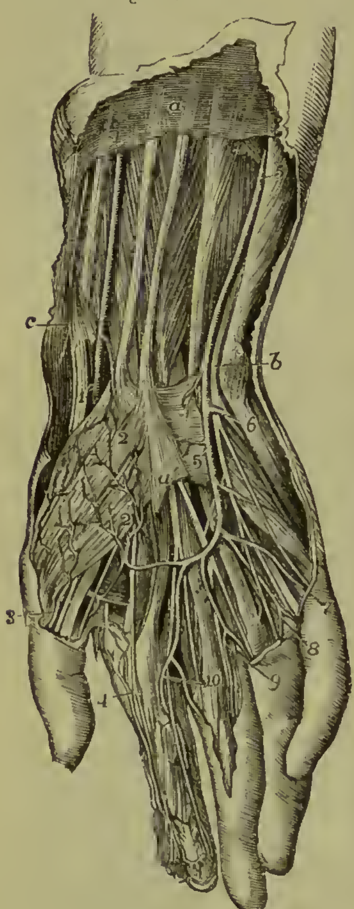


Fig. 276.—Superficial Dissection of the Lower Part of the Forearm and the Hand, showing the Radial and Ulnar Arteries, the Superficial Palmar Arch, and the accompanying Nerves (from R. Quain). ⅓

a, placed on the deep fascia of the forearm, between the tendons of the palmaris longus and flexor carpi radialis muscles; *b*, points by a line crossing the pisiform bone to the ulnar nerve; *c*, points to the styloid process of the radius and twigs of the radial nerve; 1, radial artery lying on the flexor longus pollicis; 1′, the radial artery passing behind the tendons of the extensor ossis metacarpi pollicis and extensor primi internodii pollicis; 2, superficialis volæ branch piercing the short muscles of the thumb and emerging below to join the superficial palmar arch; 3, external branch of the princeps pollicis; 4, radialis indicis; a branch from the superficial arch is seen joining the internal branch of the princeps pollicis; 5, ulnar artery lying upon the flexor digitorum profundus; 5′, the same descending on the anterior annular ligament to form the superficial palmar arch; 6, deep branch of the ulnar artery passing between the abductor and flexor minimi digiti to join the deep arch, accompanied by the deep branch of the ulnar nerve; 7, branch of the superficial arch to the ulnar side of the little finger; 8, division of the common branch to the 4th and 5th fingers; 9, the same to the 3rd and 4th fingers; 10, the same to the 2nd and 3rd fingers; 7 and 8, are accompanied by the digital branches of the ulnar nerve, and 3, 4, 9, and 10, by the branches of the median nerve.

The digital arteries are placed at first superficial to the tendons, and then lie between them, accompanied by the digital nerves as far as the clefts of the fingers, where they are joined by the anterior interosseous arteries, branches of the deep arch. On the sides of the fingers, each artery lies beneath the corresponding nerve, and gives branches which supply the sheaths of the tendons and the joints, some of them anastomosing across the front of the bones with similar branches from the opposite side. At about the middle of the last phalanx, the two branches for each finger converge and form an arch, from which proceed numerous small offsets to supply the matrix of the nail and all the structures at the tip of the finger.

[The *peculiarities* observed in the branches of the superficial palmar arch will be noticed after the description of the deep arteries of the hand.]

RADIAL ARTERY.

The *radial artery* appears by its direction to be the continuation of the brachial, although it does not equal the ulnar in size. It extends along the front of the forearm as far as the lower end of the radius, below which it

turns round the outer border of the wrist; and descends to the back of the space between the metacarpal bones of the thumb and forefinger: there it passes forwards into the palm of the hand, and crosses towards the inner side, so as to form the deeper palmar arch. In consequence of the changes in its course, the direction and connections of the radial artery may be separately described in the forearm, on the wrist, and in the hand.

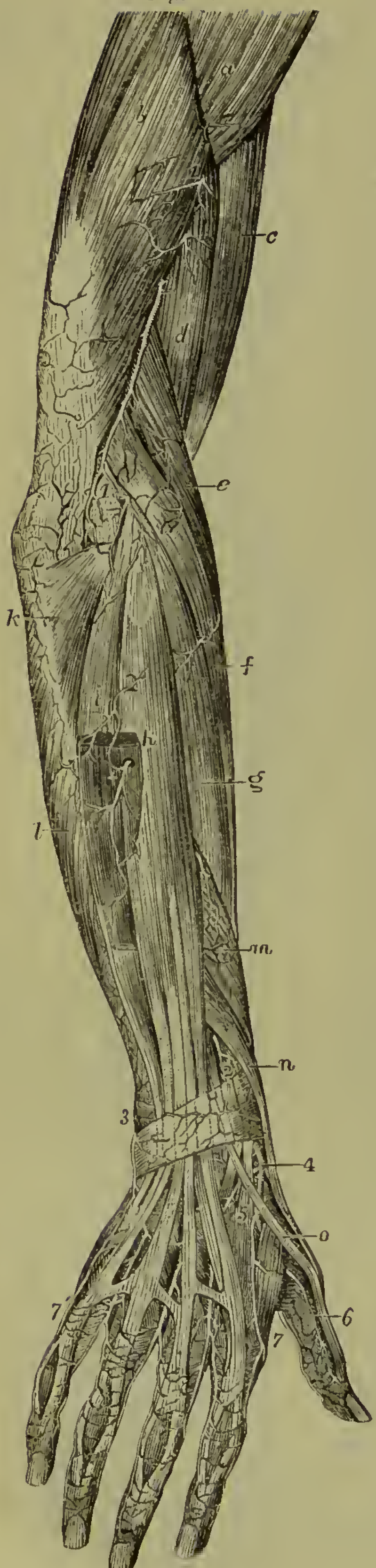
Fig. 277.

Fig. 277.—Deep Anterior View of the Arteries of the Arm, Forearm, and Hand (from Tiedemann). ¼

The biceps brachii, the pronator teres and muscles rising from the inner condyle, the supinator longus, the lower part of the flexor longus pollicis and flexor profundus digitorum, the anterior annular ligament of the carpus and the muscles of the ball of the thumb have been removed; *n*, pronator quadratus muscle; 1, lower part of the axillary artery continued into the brachial; 2, superior profunda branch; 3, inferior profunda; 4, anastomotic; 5, upper part of the radial artery and radial recurrent; 5′, lower part of the radial artery giving off the superficialis volæ branch; 5″, the radial artery emerging from between the heads of the abductor indicis muscle; 6, 6, the upper part of the ulnar artery with the anterior and posterior ulnar recurrent branches; 6′, the ulnar artery approaching the wrist and descending into the superficial palmar arch which has been cut short; 6″, the deep branch of the ulnar artery uniting with the deep palmar arch; 7 (marked only on one), three interosseous branches from the deep palmar arch joining the palmar digital arteries 8, 8, 8, which have been cut away from their origin from the superficial arch to near their division into the collateral digital arteries; the ulnar collateral of the little finger is represented as rising in this instance from the deep ulnar artery; 9, placed between the princeps pollicis and radialis indicis branches of the radial artery; 10, lower part of the anterior interosseous artery passing behind the pronator quadratus muscle; 11, anastomosis of the anterior carpal branches of the radial and ulnar arteries with recurrent branches from the deep palmar arch.

In the forearm the radial artery, commencing at the point of bifurcation of the brachial opposite the neck of the radius, descends at first somewhat obliquely outwards in a line with the brachial artery, and then nearly vertically along the outer part of the front of the forearm to the styloid process of the radius. Its course may be indicated by a line drawn from

Fig. 278.



the middle of the bend of the elbow to the narrow interval between the trapezium bone and the tendons of the extensors of the thumb, which can be readily felt on the outer border of the wrist.

Fig. 278.—Arteries of the Outer and Back Part of the Arm and Hand, Superficial View (from Tiedemann). ¼

a, deltoid muscle; *b*, external humeral head of triceps; *c*, biceps brachii; *d*, brachialis anticus; *e*, supinator longus; *f*, extensor carpi radialis longior; *g*, brevior; *h*, extensor communis digitorum and extensor minimi digiti; *i*, extensor carpi ulnaris; *k*, anconeus; *l*, flexor carpi ulnaris; *m*, extensor ossis metacarpi pollicis; *n*, extensor primi internodii pollicis; *o*, tendon of the extensor secundi internodii pollicis; 1, 1, branches of superior profunda artery appearing between the triceps and brachialis anticus, and descending on the outer supracondyloid eminence to anastomose with the branches of the recurrent radial artery; 2, above the posterior annular ligament points to the posterior carpal branch of the interosseous artery; 3, posterior carpal branch of the ulnar artery; 4, radial artery taking its course between the outer lateral ligament of the wrist-joint and the tendons of the extensor muscles before passing near 5, between the two heads of the abductor indicis: beneath the extensor tendons is seen the posterior carpal arch, giving the third and fourth dorsal interosseous arteries; 6, the inner dorsal artery of the thumb; 7, the outer dorsal artery of the index finger, and between 7, and 7′, the remaining dorsal digital vessels in the spaces between the heads of the metacarpal bones, near their communications with the palmar digital vessels.

The radial artery is nearer to the surface than the ulnar, and is covered only by the common integument and fascia, except where it is overlapped by the fleshy part of the supinator longus, which must be drawn aside in order to bring the vessel into view. At first it is in contact with the tendon of the biceps, and is supported by the fatty tissue contained in the hollow in the front of the elbow, which separates it from the short supinator muscle. It then rests in succession on the insertion of the pronator teres, the thin radial origin of the flexor sublimis, the flexor pollicis longus, the pronator quadratus, and the lower end of the radius. It is at this last point that the pulse is usually felt during life. To the inner side of this vessel lie the pronator teres in the upper part of its course, and

the flexor carpi radialis in the remainder; and on the outer side, in its whole course along the forearm, is the supinator longus muscle.

Relation to Veins.—The artery is accompanied by venæ comites, which have the usual arrangement of those veins.

Relation to Nerves.—The *radial* branch of the musculo-spiral nerve is placed on the outer side of the artery in the middle third of its course. At the elbow that nerve is separated from the artery by a considerable interval; and towards the lower end of the fore arm it turns backwards beneath the tendon of the supinator longus, to reach the dorsal aspect of the limb, and thus loses all connection with the artery. Some filaments of the *external cutaneous* nerve pierce the fascia to reach the lower part of the artery, which they accompany to the back of the carpus.

At the wrist the radial artery turns outwards between the styloid process of the radius and the carpus, beneath the tendons of the extensors of the metacarpal bone and first phalanx of the thumb, and upon the external lateral ligament of the wrist-joint, to reach the back of the carpus. It then runs downwards for a short distance, is crossed by the tendon of the extensor of the second phalanx of the thumb, and reaching the upper end of the space between the first and second metacarpal bones, turns forwards into the palm of the hand, by passing between the heads of the first dorsal interosseous muscle.

As it turns round below the end of the radius the artery is deep-seated, but afterwards comes nearer to the surface. It is accompanied by two veins and by some filaments of the external cutaneous nerve, and is crossed by subcutaneous veins and by filaments of the radial nerve.

BRANCHES.—The branches of the radial artery may be arranged according as they are given off in the fore arm, on the wrist, and in the hand.

A. The branches which arise from the radial in the fore arm are the radial recurrent, the muscular branches, the anterior carpal, and the superficial volar.

(*a*) The *radial recurrent* artery, which varies much in size, arches upwards from the radial soon after its origin, running between the branches of the musculo-spiral nerve. It first lies on the supinator brevis, and then on the brachialis anticus, being covered by the supinator longus. In front of the outer condyle, and in the interval between the two last muscles, it anastomoses with the terminal branches of the superior profunda.

From the lower or convex side of this artery are given off several branches; one, of considerable size, to the supinator and extensor muscles, and some beneath the latter to anastomose with the posterior interosseous branches. It also supplies the supinator brevis, and brachialis anticus in part.

(*b*) The *anterior radial carpal* is a small branch which arises from the radial artery, near the lower border of the pronator quadratus, and runs inwards in front of the radius. It anastomoses with the anterior ulnar carpal artery, so as to form an arch above and in front of the radio-carpal articulation, from which branches descend to supply the joints at the wrist.

(*c*) The *superficial volar* (ramus superficialis volæ), arising from the radial artery, near the place where it leaves the front of the forearm, passes onwards into the hand. In size it is variable; in most instances it is very small, and ends in the muscles of the thumb; but in others it attains considerable size, and crossing those muscles at their origins, terminates, as it is usually described, by inosculating with the radial extremity of the superficial palmar arch, which it thus completes.

Several unnamed *muscular* branches are given by the radial artery to the muscles on the fore part of the arm.

B. The branches which arise from the radial artery behind the wrist are, the posterior carpal, the metacarpal, the dorsal arteries of the thumb, and the dorsal artery of the index finger.

(*a*) The *posterior radial carpal* is a small but constant branch. It arises beneath the extensor tendons of the thumb, and running inwards on the back of the carpus anastomoses with the posterior ulnar carpal branch, completing the arch from which spring the dorsal interosseous arteries of the third and fourth spaces (p. 391). It anastomoses, also, with the terminal branch of the anterior interosseous of the fore arm.

(*b*) The *first dorsal interosseous* or *metacarpal* branch arises beneath the extensor tendons of the thumb, frequently in common with the posterior carpal branch, passes to the interval between the second and third metacarpal bones, communicates with the corresponding perforating branch of the deep palmar arch, and descending on the second dorsal interosseous muscle anastomoses with the palmar digital branch at its division between the fingers.

Fig. 279.

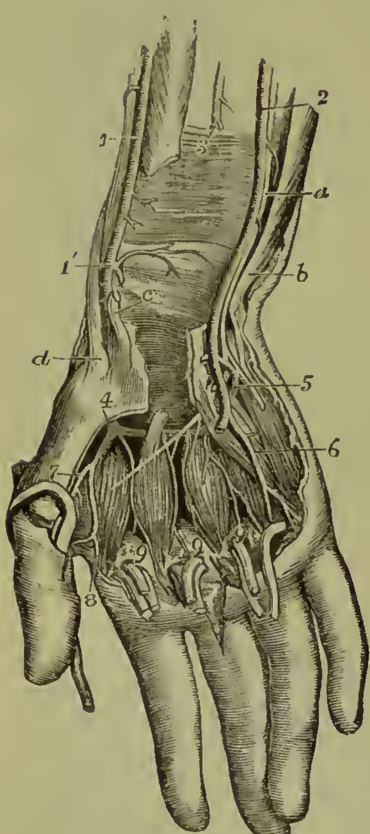


Fig. 279.—Deep View of the Arteries of the Wrist and Hand, from before (from R. Quain). ½

The anterior annular ligament of the carpus has been divided and the lower part of the common flexors and flexor of the thumb has been removed; portions of these tendons are represented as turned down upon the fingers with parts of the lumbricales muscles; the superficial palmar arch is removed, and the interossei muscles are exposed. *a*, ulnar nerve; *b*, tendon of the flexor carpi ulnaris muscle; *c*, tendon of the flexor carpi radialis; *d*, inserted tendon of the extensor ossis metacarpi pollicis; 1, radial artery; 1′, its lower part before passing back within the extensor tendons of the thumb, giving the anterior carpal and superficial volar branches; 2, ulnar artery; 3, anterior interosseous artery before passing behind the pronator quadratus muscle; 4, radial artery, appearing deeply in the palm between the first and second metacarpal bones and passing into the deep palmar arch; 5, deep branch of the ulnar artery dipping between the abductor and flexor brevis minimi digiti to join the deep arch, and accompanied by the deep branch of the ulnar nerve; 6, a palmar digital artery rising from the first part of the superficial palmar arch; 7, the princeps pollicis, and 8, the radialis indicis arteries rising from the radial artery; 9, 9, 9, interosseous branches of the deep palmar arch proceeding down on the interosseous muscles to join the palmar digital arteries from the superficial arch.

(*c*) The *dorsal arteries of the thumb*, two small branches, arising separately or together opposite the head of the metacarpal bone, run upon the dorsal aspect of the bones of the thumb, one at the radial, the other at the ulnar border.

(*d*) The *dorsal artery* of the *index finger*, a very small branch, arises

lower down than the preceding, and sending branches to the abductor indicis, runs along the radial side of the back of the index finger.

c. The branches derived from the radial after it has entered the hand, are, the great artery of the thumb, the radial branch of the index finger, and its large terminal branch, which forms the deep palmar arch.

(*a*) The *large artery of the thumb* (arteria princeps pollicis,—Haller) arises from the radial, where it is about to turn inwards across the palm of the hand. It descends in front of the abductor indicis, between the metacarpal bone of the thumb and the muscles covering it, to the space between the lower ends of the flexor brevis pollicis. At that point, and beneath the tendon of the long flexor, it divides into two *collateral branches*, which course along the borders of the phalanges, on the palmar aspect, and unite in front of the last phalanx, to form an arch similar in arrangement to that on the other fingers.

(*b*) The *radial branch for the index finger* generally arises close to the large artery of the thumb ; but though constantly found, it varies in size and in its mode of origin. It descends between the abductor indicis and adductor pollicis muscles, and continues along the radial border of the index finger, forming the radial collateral branch of that finger, and anastomosing in the usual manner on the last phalanx with the ulnar collateral branch derived from the superficial palmar arch.

This artery very frequently gives off a communicating branch to the superficial arch, near the lower border of the adductor pollicis. But the most frequent communication between the radial artery and the superficial arch is by means of the small branch which proceeds from the former through the muscles of the thumb.

PECULIARITIES.—*Origin.*—In the observations of Richard Quain, the radial artery was found to arise higher up than usual in nearly one case in eight.

Course.—The radial artery more rarely deviates from its usual position along the fore arm than the ulnar.—It has, however, been found lying upon the fibrous expansion from the tendon of the biceps, and over the fascia of the fore arm, instead of beneath those structures. This vessel has been also observed on the surface of the long supinator, instead of on the inner border of that muscle. In turning round the wrist, it has been seen passing over the extensor tendons of the thumb, instead of within them. But these several peculiarities are of very rare occurrence. As was previously stated (p. 387), the vasa aberrantia occasionally derived from the brachial or axillary arteries most commonly end by joining the radial, or one of its branches.

Branches.—The radial *recurrent* is sometimes very large, or it may be replaced by several separate branches. When the radial itself arises high up, the recurrent artery usually comes from the residual brachial trunk, or sometimes from the ulnar artery, or more rarely from the interosseous. When given from the brachial trunk, the radial recurrent has been found crossing beneath the tendon of the biceps.

The *superficial volar* branch is small in a considerable number of cases, and is lost in the short muscles of the thumb, without forming any connection with the palmar arch, or with any of the digital arteries.

In some instances in which it is enlarged, it furnishes one or two digital branches, and along with this the anastomosis with the superficial arch may be absent. The superficial volar branch occasionally arises as much as an inch and a half higher than usual.

The *first dorsal interosseous* branch (metacarpal), which descends on the second *interosseous* space to the cleft between the index and middle fingers, is not unfrequently so large as to furnish the collateral digital branch to each of those fingers.

The *carpal* and *interosseous* (metacarpal) branches of the radial are sometimes small, their place being supplied by the perforating offset of the anterior interosseous, apparently by an enlargement of the ordinary anastomosis between them.

DEEP PALMAR ARCH.

The deep palmar arch, the continuation of the radial artery, commences at the upper end of the first interosseous space between the heads of the abductor indicis, turns transversely across the palm towards the fourth metacarpal bone, and inosculates with the communicating branch of the ulnar artery. The convexity of the arch thus formed is directed downwards. It rests on the interosseous muscles and on the metacarpal bones immediately below their carpal extremities, and is covered by the flexor brevis pollicis, the flexor tendons of the fingers, and the muscles of the little finger. It is nearer to the carpus than the superficial arch, and differs from it in retaining its size almost undiminished. It is in part accompanied by the deep branch of the ulnar nerve, which runs from the inner end of the arch outwards.

Fig. 280.

Branches :—

(*a*) The *recurrent* branches (rami retrogradi,—Haller), from the upper concave side, ascend and anastomose with the branches from the anterior carpal arch.

(*b*) The *superior perforating* branches, three in number, pass backwards through the upper extremities of the last three interosseous spaces to inosculate with the dorsal interosseous arteries.

(*c*) The *palmar interosseous* arteries, usually three in number, but very liable to variation, lie in front of the interosseous spaces, supply the muscles there, and anastomose at the clefts of the fingers with the digital branches from the superficial arch.

It is by an enlargement of these small vessels that the deep palmar arch sometimes supplies the corresponding digital arteries in the absence of those usually derived from the superficial arch.

Fig. 280.—Dissection of the Left Arm, showing an enlarged Median Artery which replaces the Radial and Ulnar Arteries in the supply of Palmar Digital Arteries to half the Fingers (from Tiedemann). ¼

1, lower part of the brachial artery; 2, radial artery, not giving any superficial volar branch; 3, recurrent radial branch; 4, ulnar artery passing superficially over the wrist and supplying at 4′, digital arteries to half the hand; 5, the enlarged median artery passing in front of the annular ligament of the carpus, and supplying 5′, digital vessels to the outer half of the hand.

VARIOUS CONDITIONS OF THE ARTERIES OF THE HAND.

The arteries of the hand frequently vary from their usual mode of distribution. (*a*) By far the larger number of deviations consist of a deficiency in either the

radial or ulnar system of arteries, accompanied by a corresponding increase in the other; and it may be observed that the defect is much more commonly on the part of the superficial, and the increase on the part of the deep set.

(*b*) In a second and smaller class of variations a deficiency in one or other of the two systems is supplied, either by the enlargement of branches which descend in front of the limb, as the superficial volar (from the radial), or the median artery (from the anterior interosseous), or by the enlargement of a metacarpal branch (from the radial) on the back of the hand.

In illustration of these general remarks, the following modes of arrangement of the vessels may be mentioned :—

In the greater number of cases the superficial palmar arch is diminished, and gives off fewer digital branches than usual. Generally only one branch is wanting, viz., that which supplies the adjacent sides of the fore and middle fingers; but sometimes two or three branches are absent, or even all four, as when the ulnar artery, after giving branches to the short muscles of the little finger, ends in the deep palmar arch. In the last-mentioned case, which is rare, it is obvious that the superficial arch is altogether wanting.

These various deficiencies in the superficial palmar arch and its branches are usually compensated for by an enlargement of the deep arch, the palmar interosseous branches of which, being increased in size, divide at the clefts of the fingers, and form such collateral digital branches as are not derived from the usual source. But a defective superficial arch may, as before mentioned, be reinforced from other vessels, viz., from the superficial volar, from an enlarged median artery, or from a large metacarpal branch.

It sometimes, but more rarely, happens, that the radial system of vessels is deficient; in which case the superficial arch (which belongs to the ulnar system) may supply all the digital arteries to the thumb and fingers, or one of these may be derived from the superficial volar, the median, or the radial interosseous artery.

DESCENDING AORTA.—THORACIC AORTA.

From the point at which its arch is considered to terminate—the lower margin of the third dorsal vertebra, the aorta descends along the fore part of the spine to the fourth lumbar vertebra, where it divides into the common iliac arteries. The direction of this part of the vessel is not vertical, for as it follows the bend of the spine, upon which it rests, it is necessarily concave forwards in the dorsal region, and convex forwards in the lumbar. Again, as its commencement is at the left side of the bodies of the vertebræ, and its termination also inclined a little to the left, whilst about the last dorsal vertebra the vessel is nearly upon the median line, there is produced another slight curve, the convexity of which is to the right side. Within the thorax, where the offsets are small, the aorta diminishes only slightly in size; in the abdomen the diminution is considerable, in consequence of large branches being furnished to the viscera of that cavity.

That part of the descending aorta which is situated in the thorax, is called the *thoracic aorta*; it extends from the lower border of the third dorsal vertebra on the left side, to the opening between the crura of the diaphragm in front of the last dorsal vertebra. It lies in the back part of the interpleural space or mediastinum, being placed before the spine and behind the root of the left lung and the pericardium; on the left side it is in contact with the corresponding pleura and lung, and close on the right side are the azygos vein, the thoracic duct, and the œsophagus. The œsophagus, however, towards the lower part of the thorax is in front of the artery, and near the diaphragm gets somewhat to the left side. The left or small azygos vein crosses behind the thoracic aorta.

The *branches* derived from the thoracic aorta are numerous, but small.

They are distributed to the walls of the thorax, and to the viscera contained within it—the latter being much the smaller and least numerous branches.

A. The *branches to the viscera* aro very irregular in their number and place of origin. They are as follows :—

The *pericardiac branches* are some very small and irregular vessels which pass forwards and ramify on the pericardium.

The Bronchial Arteries are the proper nutritious arteries of the substance of the lung : they accompany the bronchial tubes in their ramifications through that organ, and they also supply the bronchial glands, and in part the œsophagus. These vessels vary frequently in number, and in their mode of origin. The bronchial artery of the right side arises from the first aortic intercostal artery, or by a common trunk with the left bronchial artery from the thoracic aorta ; on the left side there are generally two bronchial arteries, both of which arise from the thoracic aorta, one near the commencement of that trunk, and the other, named inferior bronchial, lower down. Each artery is usually directed to the back part of the corresponding bronchus, along which it runs, dividing and subdividing with the successive bronchial ramifications in the substance of the lung.

Peculiarities of the bronchial arteries.—The place of origin is liable to much variation. The artery of the right side has been found to arise singly from the aorta, from the internal mammary, or from the inferior thyroid. The bronchial arteries of the two sides have been seen to arise by a common trunk from the subclavian. (Haller.) Two common trunks, each furnishing a branch to the right and left lungs, have been observed in a single case to descend into the thorax after arising, one from the internal mammary, and the other from the superior intercostal artery. (R. Quain, pl. 26, f. 5.) Instances occur of two distinct bronchial arteries for each lung.

The Œsophageal Arteries aro variable in size and number. There are usually four or five, which arise from the fore part or right side of the aorta, and run obliquely downwards upon the œsophagus, supplying its coats.

Their lower branches anastomose with the ascending offsets of the coronary artery of the stomach, while their upper branches communicate with those of the inferior thyroid artery.

Posterior mediastinal branches of the aorta, small and irregular, supply the glands and loose tissue of the posterior mediastinum.

B. Tho branches furnished by the aorta to the walls of the thorax are named intercostal from their distribution.

The intercostal arteries arise from the posterior part of the aorta, and run outwards upon the bodies of the vertebræ, to reach the intercostal spaces. They are usually ten in number—the upper intercostal space, and occasionally also the second, being supplied by the superior intercostal branch of the subclavian artery. Owing to the position of the aorta to the left side of the spine, the right aortic intercostals cross over the front of the vertebræ, furnishing small branches to their interior, and are longer than the arteries of the left side. The vessels of both sides pass outwards behind the pleura, and are crossed by the sympathetic nerve : those of the right side also pass behind the œsophagus, the thoracic duct, and the azygos vein.

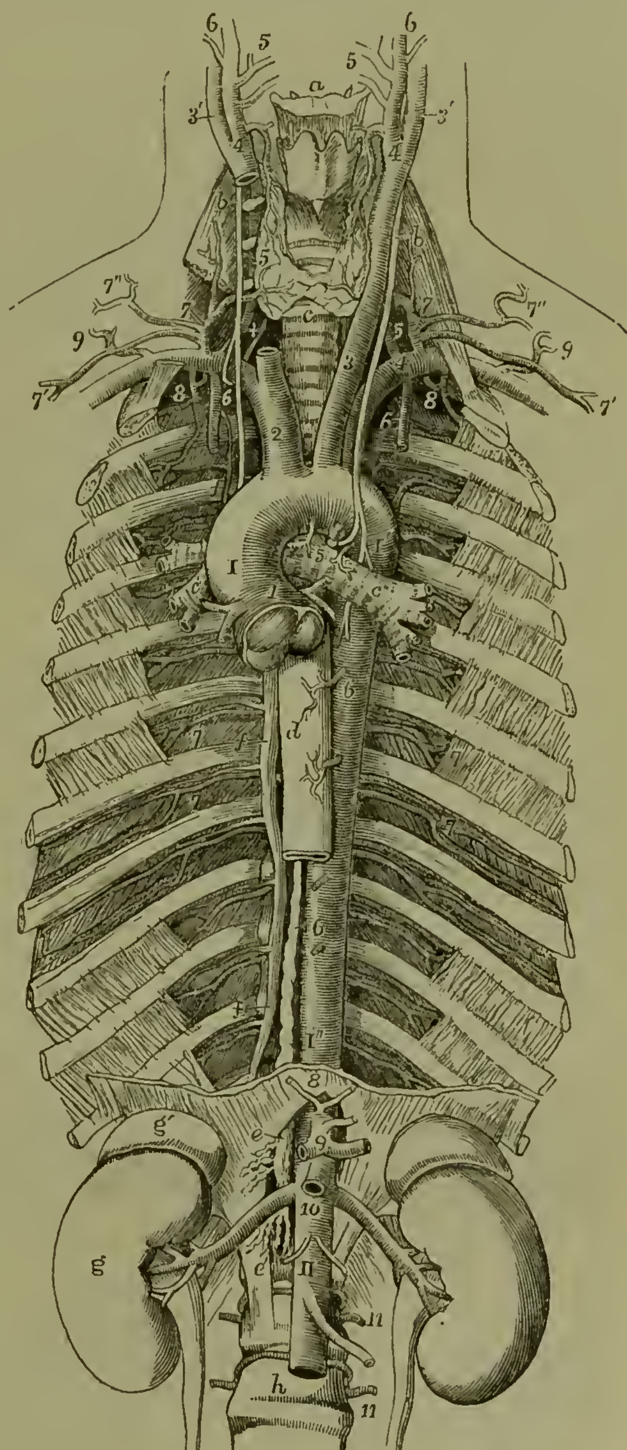
In each intercostal space the artery, passing outwards more horizontally than the ribs, crosses the space obliquely, so as to gain the lower border of the upper rib near its angle. It lies upon the deep surface of the external intercostal muscle, and in the back of the space

is separated from the pleura by a fascia only, but further outwards it lies between the two layers of intercostal muscles. Extending forwards in con-

Fig. 281.—View of the Thoracic and Upper Part of the Abdominal Aorta, &c. ¼

For the general description of this figure, see p. 334. The following numbers indicate the branches of the aorta; 1, placed between the origins of the right and left coronary arteries; 2, innominate; 3, left carotid; 4, left subclavian; 5, bronchial; 6, 6, œsophageal; 7, 7, intercostal arteries (sixth and seventh); 8, inferior phrenic; 9, cœliac axis; 10, below the superior mesenteric and opposite the origin of the renal arteries; 11, 11, two of the lumbar arteries.

Fig. 281.



tact with the rib above, it finally anastomoses with one of the anterior intercostal branches derived from the internal mammary artery, and with the thoracic branches of the axillary artery.

The first of the aortic intercostal arteries has an anastomosis with the superior intercostal proceeding from the subclavian artery; and the last three are prolonged into the abdominal muscles, where they communicate with the epigastric artery in front, with the phrenic arteries at the side, and with the lumbar branches of the abdominal aorta lower down.

Each intercostal artery is accompanied, as it runs outwards between the ribs, by a corresponding vein, and by one of the dorsal nerves; the vein usually being uppermost, and the artery next below it.

Branches.—The named branches of the intercostal arteries are the following :—

(*a*) The *posterior or dorsal* branch of each intercostal artery passes backwards to the inner side of the anterior costo-transverse ligament, along with the posterior branch of the corresponding spinal nerve ; and having furnished an offset to the spinal canal, reaches the muscles of the back, and divides into an internal and an external branch. The internal branch is directed towards the spinous processes, on or through the multifidus spinæ, and ramifies in the muscles and the skin. The external branch turns outwards under the longissimus dorsi, and is distributed between that muscle and the sacro-lumbalis ; some twigs reach the superficial muscles and the integuments.

The *spinal* branches of the aortic intercostal arteries are distributed partly to the cord and its membranes, and partly to the bones, in the same manner as the spinal branches of the lumbar arteries, to the description of which the reader is referred.

(*b*) The *collateral intercostal* branch, long and slender, arises near the place where the main trunk comes in contact with the upper rib of the space, and inclining downwards approaches the border of the lower rib, supplying the bone and the intercostal muscles, and anastomosing in front with an anterior intercostal branch of the internal mammary artery. There are thus in each intercostal space two terminal branches of the intercostal arteries communicating with the branches of the internal mammary.

ABDOMINAL AORTA.

The aorta, after having passed the diaphragm, is thus named. It commences on the front of the last dorsal vertebra, and terminates below by dividing into two trunks, named the common iliac arteries. The bifurcation usually takes place about half way down the body of the fourth lumbar vertebra, a little to the left of the middle line ; a point which is nearly on a level with a line drawn from the one crista ilii to the other, and opposite the left side of the umbilicus.

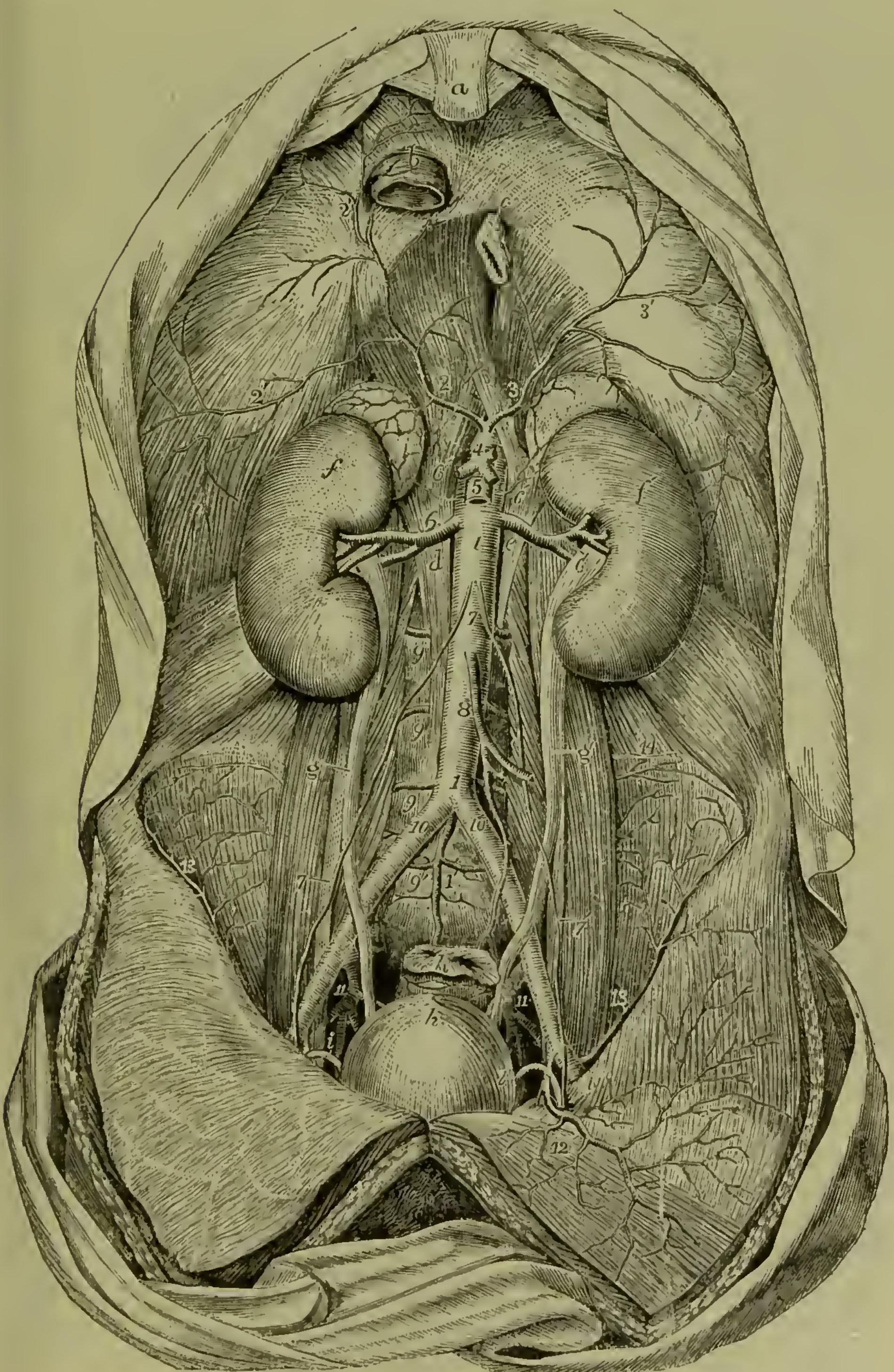
The anterior surface of the abdominal aorta is successively in apposition with the pancreas and the splenic vein, the left renal vein, the third portion of the duodenum, and the peritoneum. The vena cava lies along its right side, the right crus of the diaphragm being interposed at the upper part of the abdomen ; close to the same side are the thoracic duct and the azygos vein, which are placed between the aorta and the right crus of the diaphragm. The aorta is also covered in front by meshes of nerves derived from the sympathetic, and numerous lymphatic vessels and glands.

Fig. 282.—View of the Abdominal Aorta and its Principal Branches (from Tiedemann). ¼

a, ensiform portion of the sternum ; *b*, vena cava inferior passing through the tendon of the diaphragm ; *c*, the œsophagus passing through the muscular portion ; *d*, tendinous part of the right, *e*, of the left crus ; *f*, *f′*, the right and left kidneys with their supra-renal bodies ; *g*, *g′*, the ureters ; *h*, the upper part of the urinary bladder ; *i*, *i*, the right and left vasa deferentia passing up from the bladder to the internal inguinal apertures ; *k*, the rectum, divided and tied near its upper part ; 1, 1, the abdominal aorta ; 1′, the middle sacral artery ; 2, 2′, the right, 3, 3′, the left inferior phrenic arteries, represented as arising by a short common stem from the front of the aorta immediately below the meeting of the crura of the diaphragm ; 4, the trunk of the cœliac axis ; 5, the superior mesenteric artery ; 6, 6, the renal arteries ; 6′, 6′, the suprarenal arteries arising partly

from the aorta and partly from the inferior phrenic ; 7, placed on the front of the aorta below the origin of the spermatic arteries ; 7, 7′, placed on the psoas muscles, point to the right and left spermatic arteries as they descend to the internal inguinal apertures ; 8, inferior mesenteric artery ; 9, lumbar arteries, of which the lowest is here represented as proceeding from the middle sacral artery ; 10, common iliac arteries ; 11, between the external and internal iliac arteries ; 12, left epigastric artery ; 13, circumflex iliac ; 14, branches of the ilio-lumbar.

Fig. 282.



Branches.—The abdominal aorta gives numerous branches, which may be divided into two sets, viz., those which supply the viscera, and those which are distributed to the walls of the abdomen. The former consists of the cœliac artery, the superior mesenteric, the inferior mesenteric, the capsular, the renal, and the spermatic arteries; whilst in the latter are included the phrenic, the lumbar, and the middle sacral arteries. The three first of the visceral branches are single arteries.

Peculiarities.—*Point of division.*—In more than three-fourths of a considerable number of cases, the aorta divided either upon the fourth lumbar vertebra, or upon the intervertebral disc below it; in one case of nine it was below, and in about one of eleven above the spot thus indicated. In ten bodies out of every thirteen, the division of the great artery took place within half an inch above or below the level of the iliac crest; and it occurred more frequently below than above the fourth intervertebral space. (R. Quain, op. cit. p. 415.) An instance of bifurcation immediately below the origin of the right renal artery is recorded by Haller (Disputat. Anatom. t. vi. p. 781).

Unusual Branch.—A very remarkable case is recorded of the existence of a large pulmonary branch which arose from the abdominal aorta, close to the cœliac artery, and after passing upwards through the œsophageal opening in the diaphragm, divided into two branches, which were distributed to the lungs near their bases. (Referred to by R. Quain in his work "On the Arteries," p. 416.)

A.—VISCERAL BRANCHES OF THE ABDOMINAL AORTA.

I. CŒLIAC ARTERY OR AXIS.

The *cœliac artery*, a short and wide vessel, arises from the aorta close to the margin of the diaphragm. It is directed forwards nearly horizontally, and is not more than half an inch long. It is behind the small omentum, and lies close to the left side of the lobulus Spigelii of the liver, and above the pancreas, the two semilunar ganglia being contiguous to it, one on each side. This artery divides into three branches, viz., the coronary artery of the stomach, the hepatic and the splenic, which separate simultaneously from the end of the artery like radii from an axis.

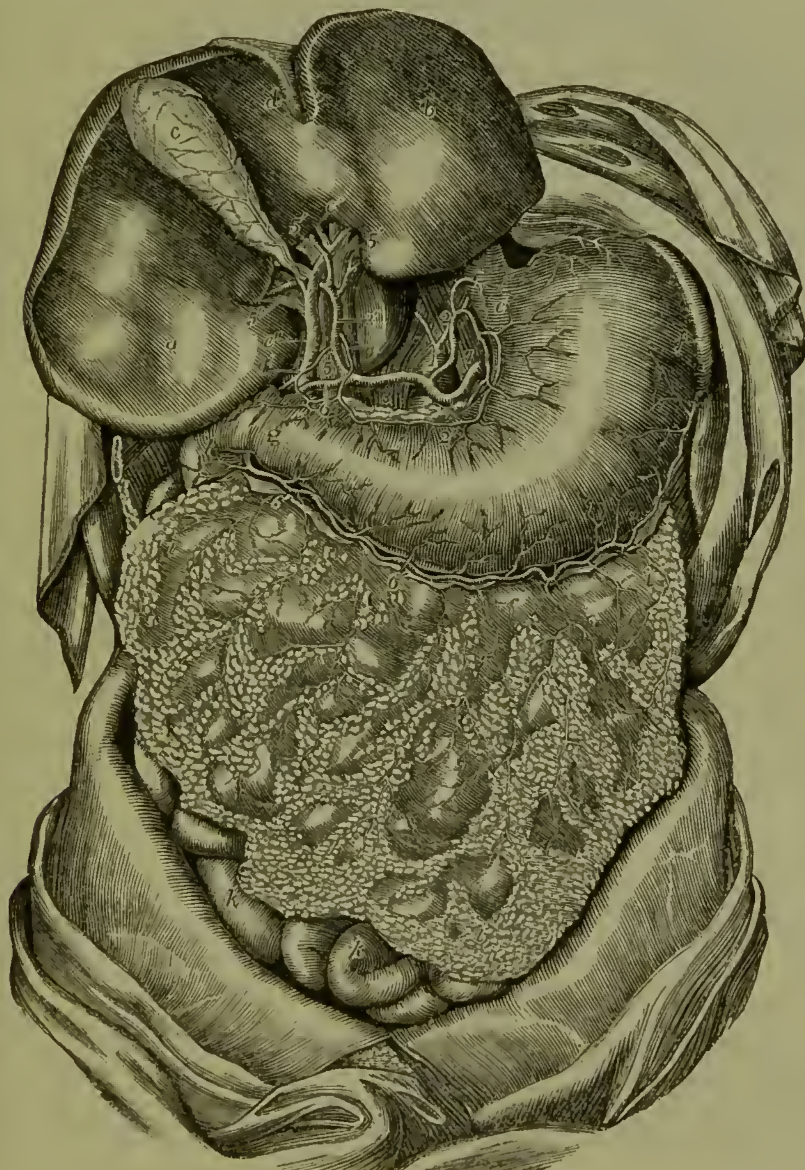
Peculiarities.—The *cœliac axis* is occasionally partly covered at its origin by the diaphragm. It may be longer than usual, in which case its branches are not given off together; or it may be entirely wanting, the coronary, hepatic, and splenic arteries arising separately from the aorta. In some cases the cœliac artery gives off only two branches at its division (the coronary and the splenic), the hepatic being supplied from another source. Rarely, it gives more than three branches to the viscera, the additional vessel being a second coronary, or a separate gastro-duodenal artery. One or both phrenic arteries are sometimes derived from this trunk. Cases have been met with in which a connection existed between the cœliac axis and the superior mesenteric artery close to their origin.

Fig. 283.—The Arteries of the Stomach, Liver, and Omentum (from Tiedemann). $\frac{1}{4}$

The liver is turned up so as to show its lower surface with the transverse fissure or porta, and the vessels and ducts entering it. *a*, the right lobe of the liver; *b*, the left lobe; *c*, the gall bladder; *c'*, the biliary or hepatic ducts; *c''*, the ductus communis choledochus; *d*, the front of the antero-posterior fissure and the round ligament; *e*, the cardiac orifice of the stomach; *f*, on the great curvature of the stomach near its cardiac end, points to the spleen; *g*, the pylorus; *h*, the duodenum; *i*, the great omentum; *k*, some of the small intestines in the lower part of the abdomen; 1, upon the trunk of the abdominal aorta, below the root of the inferior phrenic arteries, and above the cœliac axis; 2, placed on the meeting of the crura of the diaphragm, the coronary artery of the stomach; 2', the same artery proceeding round the small curvature of the stomach and ending by anastomosis with the superior pyloric; 3, the main hepatic artery, continued

at 3′ as proper hepatic artery to the liver; 4, superior pyloric artery; 4′, another pyloric branch; 5, placed on the main trunk of the vena portæ at the place where the hepatic artery and ductus communis choledochus are in front of it; 5′, branches of the vena portæ in the transverse fissure; 6, gastro-duodenal artery; 6′, its continuation as the right gastro-epiploic; 7, on the left crus of the diaphragm, the splenic artery; 8, its left gastro-epiploic branch proceeding round the great curvature of the stomach to communicate with the right gastro-epiploic artery; both of these vessels are seen giving long epiploic as well as gastric branches.

Fig. 283.



1. The Coronary Artery of the Stomach, the smallest of the three visceral branches derived from the cœliac artery, inclining upwards and to the left side, reaches the cardiac orifice of the stomach, and then proceeding along the smaller curvature of the stomach, from left to right, gives branches to both sides of that viscus and inosculates with the pyloric branch of the hepatic artery.

Where it first reaches the stomach, this artery sends upwards *œsophageal branches*, which anastomose with the aortic œsophageal arteries. The branches to the stomach,

descending on the fore and back part of the organ, anastomose with branches from the arterial arch on the great curvature.

The coronary artery of the stomach is sometimes given off directly from the aorta : and is occasionally replaced by two separate vessels. It sometimes furnishes an additional hepatic artery.

2. The Hepatic Artery is in the adult intermediate in size between the coronary and splenic arteries, but, in the fœtus, it is the largest of the three. The main part of this vessel inclines upwards and to the right side, between the layers of the small omentum, and in front of the foramen of Winslow, towards the transverse fissure of the liver ; and in this course it lies upon the vena portæ and to the left of the bile duct.

Near the transverse fissure of the liver, the hepatic artery divides into right and left branches, which supply the corresponding lobes of that organ. The *left*, the smaller division, lying in front of the vena portæ, diverges at an acute angle from the other branch, and turns outwards to reach the left extremity of the transverse fissure of the liver, where it enters that organ.

The *right hepatic* artery inclines outwards to the right extremity of the transverse fissure, and divides into two or three branches before entering the liver. The ramifications of the hepatic artery in the liver accompany the divisions of the venæ portæ and hepatic ducts.

Branches.—The named branches of the hepatic artery are as follow :—

(*a*) The *pyloric* artery, coming in contact with the stomach at the upper border of the pylorus, extends from right to left along the smaller curvature and inosculates with the coronary artery. It is sometimes a branch of the gastro-duodenal.

(*b*) The *gastro-duodenal* artery, of considerable size, separating from the hepatic artery before that vessel ascends in the small omentum, descends behind the duodenum, near the pylorus, and reaches the lower border of the stomach ; there it gives off the pancreatico-duodenal branch, and its remaining part, which receives the name of right gastro-epiploic, runs from right to left along the great curvature of the stomach, between the layers of the great omentum, and finally inosculates with the left gastro-epiploic derived from the splenic artery.

The *gastro-epiploic* artery gives branches upwards to both surfaces of the stomach, and long slender vessels downwards to the omentum.

The *pancreatico-duodenal* branch descends along the inner margin of the duodenum, between it and the pancreas, and, after furnishing several branches to both these organs, anastomoses with a small offset of the superior mesenteric artery.

(*c*) The *cystic* artery, given off by the right hepatic when crossing behind the cystic duct, turns upwards and forwards upon the neck of the gall-bladder, and divides into two smaller branches, of which one ramifies between the coats on the depending surface, the other between the bladder and the liver.

Peculiarities.—The hepatic artery sometimes arises from the superior mesenteric artery, or from the aorta itself. Accessory hepatic arteries are often met with, usually coming from the coronary artery of the stomach. The hepatic artery has been found to furnish a phrenic branch.

3. The Splenic Artery, in the adult the largest branch of the cœliac artery, supplies the spleen, and in part the stomach and pancreas. It is directed horizontally towards the left side. Waving and often tortuous in its course, it passes, together with the splenic vein which is below it, behind

the upper border of the pancreas, and divides near the spleen into several branches. The largest of these enter the fissure in that organ, and are distributed to its substance ; three or four are reflected towards the bulging end of the stomach, upon which they ramify.

Fig. 284.

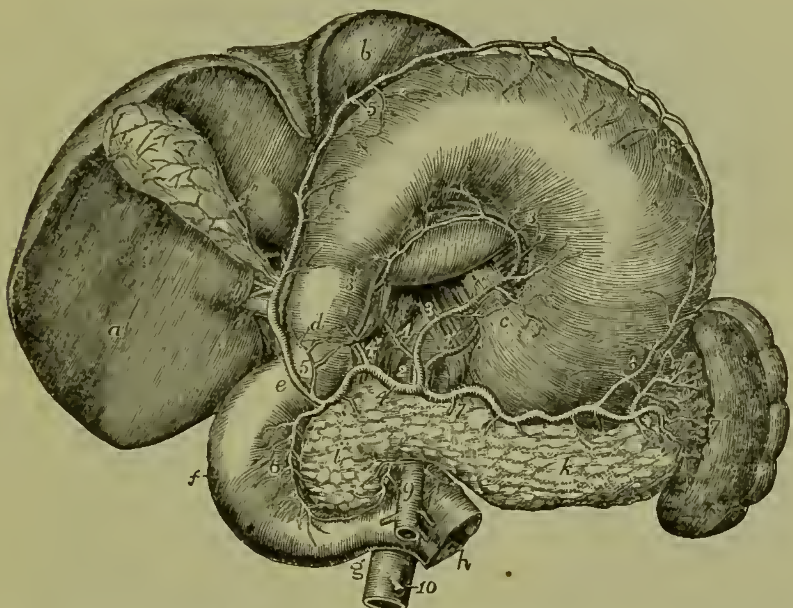


Fig. 284.—The Arteries of the Stomach, Duodenum, Pancreas, and Spleen (from Tiedemann). $\frac{1}{4}$

The stomach and liver are turned upwards so as to show their lower surface. The jejunum is divided at its commencement. *a*, lower surface of the right lobe of the liver; *b*, left lobe; *c*, cardiac orifice of the stomach ; *d*, pylorus ; *e*, first part, *f*, second or descending part, and *g*, third or lower part of the duodenum ; *h*, commencement of the jejunum emerging from behind the superior mesenteric artery ; *i*, the head, and *k*, the body of the pancreas ; *l*, the spleen ; 1, 1, right and left inferior phrenic arteries passing from the aorta upon the crura of the diaphragm ; 2, placed on the aorta close to the cœliac axis ; 3, 3′, the coronary artery ; 4, common hepatic ; 4′, proper hepatic artery ; 4″, cystic branch ; 5, gastro-duodenal giving the inferior pyloric ; 5, on the great curvature of the stomach, the right gastro-epiploic ; 6, pancreatico-duodenal ; 7, common splenic ; 7′, proper splenic ; 7″, one of the vasa brevia to the stomach ; 8, 8, left gastro-epiploic artery uniting with the right on the great curvature of the stomach ; 9, trunk of the superior mesenteric artery, giving a small branch to join the pancreatico-duodenal ; 10, inferior mesenteric.

Branches.—(*a*) *Pancreatic* branches, variable in size and number, are given off whilst the artery is passing along the pancreas, the middle and left part of which they supply with vessels. One of larger size not unfrequently runs from left to right in the direction of the pancreatic duct, and is called *pancreatica magna.*

(*b*) The *splenic* branches are the proper terminal branches of the artery ; they are five or six, or even more, in number, and vary in length and size ; they enter the spleen by the hilus or fissure in its concave surface, and ramify within that organ.

(*c*) The *short gastric* branches (*vasa brevia*) vary from five to seven in number ; they are directed from left to right, some issuing from the trunk of the splenic artery, others from its terminal branches : they reach the left extremity of the stomach, where they divide and spread out between the coats, communicating with the coronary and left gastro-epiploic arteries.

(*d*) The left *gastro-epiploic* artery runs from left to right along the great curvature of the stomach, supplying branches to both surfaces of the stomach and to the omentum on the left side, and inosculates with the right gastro-epiploic branch from the hepatic artery.

II. SUPERIOR MESENTERIC ARTERY.

The superior mesenteric, an artery of large size, supplies the whole of the small intestine beyond the duodenum, and half of the great intestine. It arises from the fore part of the aorta, a little below the cœliac artery. For a short space this artery is covered by the pancreas; on emerging from below that gland it descends in front of the duodenum near the end, and is thence continued between the layers of the mesentery. The splenic vein crosses over its root. In the mesentery the artery at first passes downwards and to the left side, but afterwards turns towards the right iliac fossa, opposite to which it inosculates with its own ileo-colic branch.

BRANCHES.—(*a*) The *inferior pancreatico-duodenal*, given off under cover of the pancreas, runs along the concave border of the duodenum, and joins with the pancreatico-duodenal artery.

(*b*) The *rami intestini tenuis*, or intestinal branches, supplying the jejunum and ileum, spring from the convex or left side of the vessel. They are usually twelve or more in number, and are all included between the layers of the mesentery. They run parallel to one another for some distance, and then divide into two branches, each of which forms an arch with the neighbouring branch. From the first set of arches other branches issue, which divide and communicate in the same way, until finally, after forming four or five such tiers of arches, each smaller than the other, the ultimate divisions of the vessels proceed directly to the intestine, spreading upon both sides, and ramifying in its coats.

(*c*) The *colic* branches arise from the right or concave side of the artery, and are three in number.

1. The *ileo-colic* artery, the first in order from below upwards, inclines downwards and to the right side, towards the ileo-colic valve, near which it divides into two branches: one of these descends to inosculate with the termination of the mesenteric artery itself, and to form an arch, from the convexity of which branches proceed to supply the junction of the small with the large intestine, and the cæcum and its appendix; the other division ascends and inosculates with the next mentioned branch. The ileo-colic artery is not always distinct from the termination of the superior mesenteric.

2. The *right colic* artery passes transversely towards the right side, beneath the peritoneum, to the middle of the ascending colon, opposite to which it divides into two branches, of which one descends to communicate with the ileo-colic artery, whilst the other ascends to join in an arch with the middle colic. This artery and the ileo-colic often arise by a common trunk.

3. The *middle colic* artery passes upwards between the layers of the meso-colon towards the transverse colon, and divides in a manner exactly similar to that of the vessels just noticed. One of its branches inclines to the right, where it inosculates with the preceding vessel; the other descends to the left side, and maintains a similar communication with the left colic branch, derived from the inferior mesenteric artery. From the arches of inosculation thus formed, small branches pass to the colon for the supply of its coats.

Those branches of the superior mesenteric artery which supply the ascend-

Fig. 285.

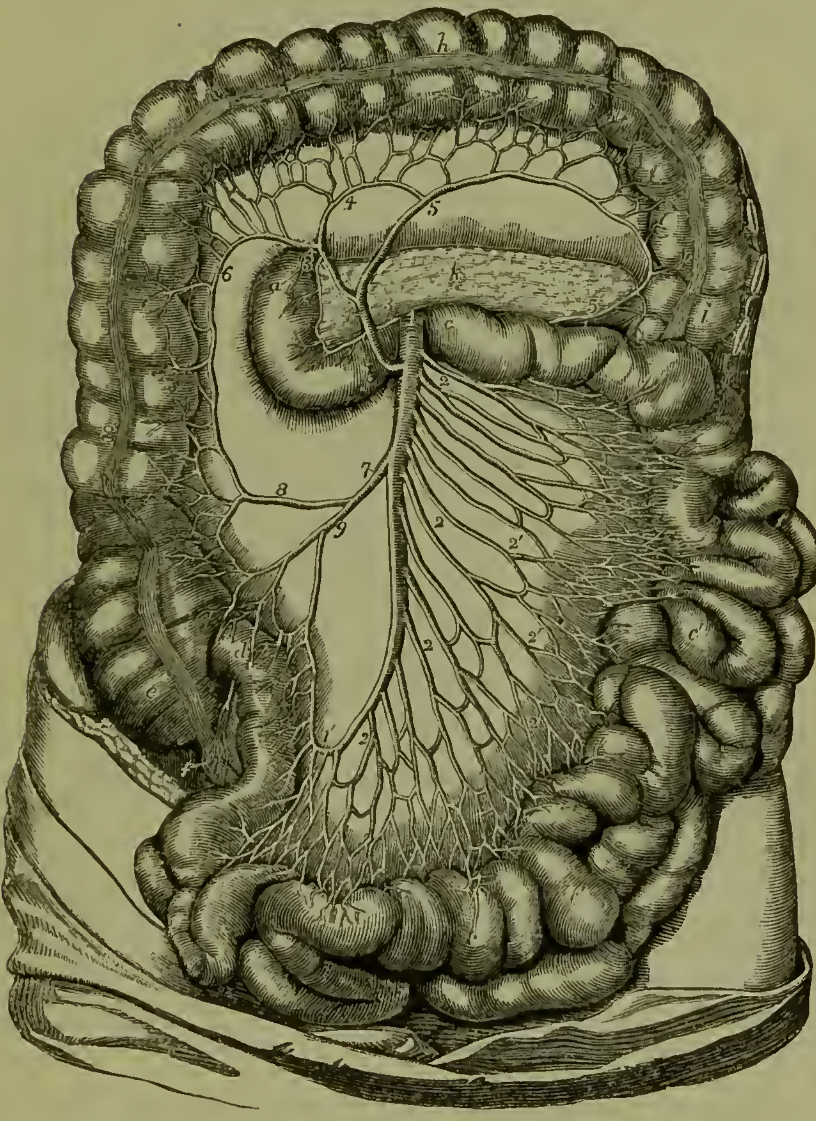


Fig. 285.—THE SUPERIOR MESENTERIC ARTERY, AND ITS BRANCHES (from Tiedemann). ¼

The transverse arch of the colon is turned upwards; the transverse meso-colon is dissected so as to expose the duodenum and pancreas at its root; the small intestines are thrown towards the left side; *a*, the descending part of the duodenum; *b*, the lower part before it passes behind the superior mesenteric artery and root of the mesentery; *c*, the commencement of the jejunum to the left of the root of the mesentery; *c′*, *c′*, the jejunum and ileum; *d*, the termination of the ileum in the caput cæcum coli; *e*, the cæcum; *f*, the vermiform process; *g*, the ascending colon; *h*, the transverse arch; *i*, the descending colon; *k*, the pancreas; 1, the trunk of the superior mesenteric artery; 1′, the termination of that vessel where it loops round into a branch of the ileo-colic artery; 2, 2, 2, 2, the intestinal branches; 2′, 2′, 2′, several of their loops in the mesentery; 3, small pancreatico-duodenal branch passing to 3′, to unite with the branch from the gastro-duodenal; 4, the middle colic branch; 5, its left colic branch passing at 5′ to unite with the branch of the left colic of the inferior mesenteric; 6, right branch; 7, right colic and ileo-colic arteries in one trunk; 8, right colic, uniting by a loop with the middle colic; 9, the ileo-colic, uniting with the end of the superior mesenteric artery.

ing colon have a layer of peritoneum only on their anterior aspect: the others lie between two strata.

The superior mesenteric artery is occasionally connected at its origin with the cœliac artery. Not unfrequently it furnishes the hepatic artery.

III. INFERIOR MESENTERIC ARTERY.

This artery, much smaller than the superior mesenteric, supplies the lower half of the colon, and the greater part of the rectum. It arises from the aorta, between an inch and two inches above the bifurcation of that trunk.

The inferior mesenteric artery inclines to the left side in the direction of the left iliac fossa, from which point it descends between the layers of the meso-rectum into the pelvis, and under the name of "superior hæmorrhoidal" artery, runs down behind the rectum. It lies at first close to the aorta, on its left side, and then crosses over the left common iliac artery.

BRANCHES.—(*a*). The *left colic* artery is directed to the left side behind the peritoneum, and across the left kidney to reach the descending colon. It divides into two branches, and forms a series of arches in the same way as the colic vessels of the opposite side. One of these two branches passes upwards along the colon, and inosculates with the descending branch of the middle colic; whilst the other descends towards the sigmoid flexure, and anastomoses with the sigmoid artery.

(*b*) The *sigmoid* artery runs obliquely downwards to the sigmoid flexure of the colon, where it divides into branches; some of which incline upwards and form arches with the preceding vessel, while others turn downwards to the rectum and anastomose with the following branch. Instead of a single sigmoid artery, two or three branches are sometimes present.

(*c*) The *superior hæmorrhoidal* artery, the continuation of the inferior mesenteric, passes into the pelvis behind the rectum, at first in the meso-rectum, and then divides into two branches which extend one on each side of the intestine towards the lower end. About five inches from the anus these subdivide into branches, about a line in diameter, which pierce the muscular coat two inches lower down. In the intestine, these arteries, about seven in number, and placed at regular distances from each other, descend between the mucous and muscular coats to the end of the gut, where they communicate in loops opposite the internal sphincter, and end below by anastomosing with the middle and inferior hæmorrhoidal arteries.

ANASTOMOSES ON THE INTESTINAL TUBE.—The arteries distributed to the alimentary canal communicate freely with each other over the whole length of that tube. The arteries of the great intestine derived from the two mesenteric arteries, form a range of vascular arches along the colon and rectum, at the lower end of which they anastomose with the middle and inferior hæmorrhoidal arteries, given from the internal iliac and pudic arteries. The branches from the left side of the superior mesenteric form another series of arches along the small intestine, which is connected with the former by the ileo-colic artery. Farther, a branch of the superior mesenteric joins upon the duodenum with the pancreatico-duodenal artery. The latter, at its commencement, is in a manner continuous with the pyloric artery; and so likewise, through the coronary artery of the stomach and its ascending branches, a similar connection is formed with the œsophageal arteries, even up to the pharynx.

Fig. 286.

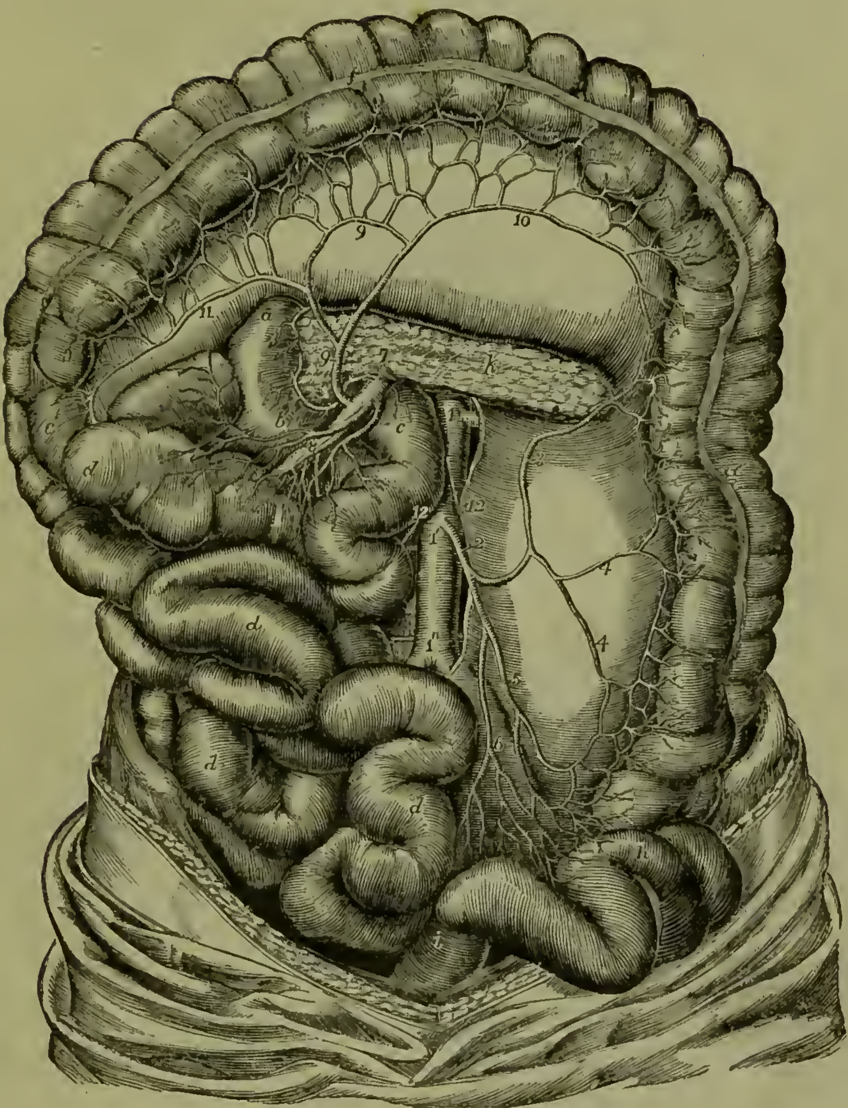


Fig. 286.—The Inferior Mesenteric Artery with its distribution and communications (from Tiedemann). $\frac{1}{4}$

The small intestines with the superior mesenteric artery are turned towards the right side, the pancreas is exposed, and the large intestine is stretched out: *a*, *b*, the duodenum; *c*, the commencement of the jejunum; *d*, the small intestine; *e*, the ascending colon; *f*, the transverse colon; *g*, the descending colon; *h*, the sigmoid flexure; *i*, the commencement of the rectum; *k*, the pancreas; 1, placed on the trunk of the abdominal aorta at the origin of the renal arteries; 1′, on the same at the origin of the inferior mesenteric; 1″, near the division into common iliac arteries; 2, inferior mesenteric, giving off first the left colic; 3, ascending branch of the left colic; 4, branches to the descending colon; 5, the sigmoid branch; 6, the superior hæmorrhoidal branch; 7, the trunk of the superior mesenteric issuing from behind the pancreas; 8, some of its intestinal branches; 9, the middle colic artery; 10, its left branch forming a loop of communication with the left colic; 11, its right branch; 12, the spermatic arteries.

IV. CAPSULAR OR SUPRARENAL ARTERIES.

The suprarenal or capsular arteries are two very small vessels which arise from the aorta on a level with the superior mesenteric artery, and incline

obliquely outwards upon the crura of the diaphragm to reach the suprarenal capsules, to which bodies they are distributed, anastomosing at the same time with the other capsular branches derived from the phrenic and the renal arteries. In the fœtus these arteries are of larger size.

V. RENAL OR EMULGENT ARTERIES.

The renal arteries, of large diameter in proportion to the size of the organs which they supply, arise from the sides of the aorta, about half an inch below the superior mesenteric artery, that of the right side being rather lower down than that of the left. Each is directed outwards, so as to form nearly a right angle with the aorta. In consequence of the position of the aorta upon the spine, the right renal artery has to run a somewhat longer course than the left, in order to reach the kidney. The artery of the right side crosses behind the vena cava, and both right and left arteries are overlapped by the accompanying renal veins. Previously to reaching the concave border of the kidney, each artery divides into four or five branches, the greater number of which usually lie intermediate between the vein in front and the pelvis of the kidney behind. These branches, after having passed deeply into the fissure of the kidney, subdivide and are distributed in the gland, in the manner described in the account of the structure of that organ.

Branches.—The renal artery furnishes a small branch to the suprarenal capsule, a second to the ureter, and several others which ramify in the connective tissue and fat behind the kidney.

Peculiarities.—The *renal* artery may be replaced by two, three, four, or even five branches; and the greatest difference as to the origin of these vessels is found to exist even on opposite sides of the same body. As they usually arise in succession from the aorta itself, it would seem as if the deviation were merely a degree beyond that in which the single artery divides into branches sooner than usual after its origin. In some cases a renal artery has been seen to proceed from the common iliac; and in one case, described by Eustachius, from the internal iliac. Portal found in one instance the right and left renal arteries arising by a common trunk from the fore part of the aorta. In another case, one of several arteries arose from the front of the aorta at its bifurcation; or from the left common iliac at its origin.

The branches of the renal artery, instead of entering at the hilus, may reach and penetrate the gland near its upper end, or on its anterior surface. Lastly, cases occur, though very rarely, in which one of the renal arteries is wanting.

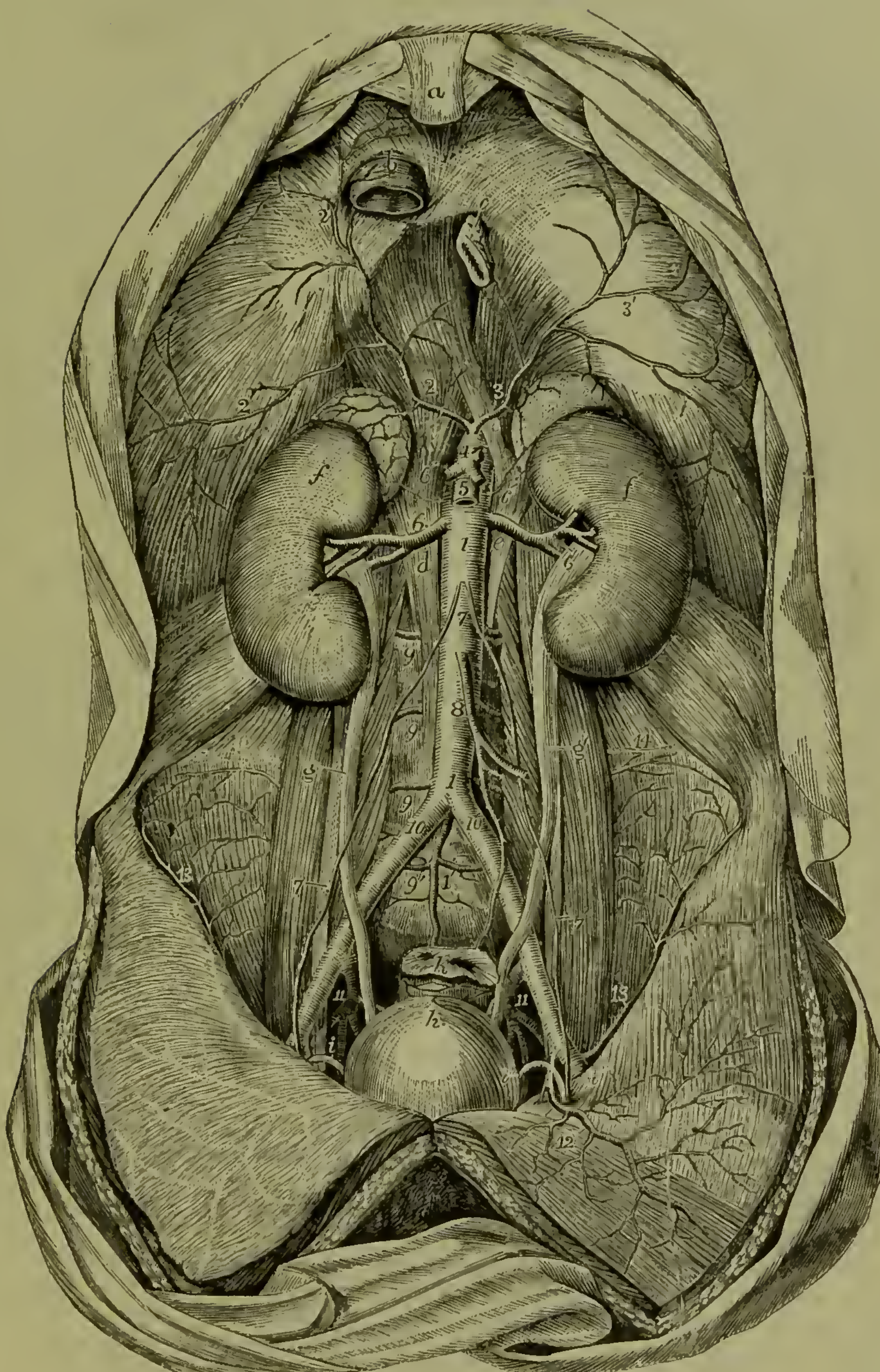
VI. SPERMATIC AND OVARIAN ARTERIES.

The spermatic arteries, two small and very long vessels, arise close together from the fore part of the aorta a little below the renal arteries. Each artery is directed downwards and outwards, resting on the psoas muscle; it crosses obliquely the ureter and, afterwards, the external iliac artery, and turns forward to the internal abdominal ring. There it comes in contact with the vas deferens, and, separating from the peritoneum, passes with the other constituents of the spermatic cord along the inguinal canal, and descends to the scrotum, where it becomes tortuous, and reaching the back part of the testis anastomoses with the artery of the vas deferens, and finally divides into branches which pierce the fibrous capsule of the testis.

Fig. 287.—View of the Abdominal Aorta and its Principal Branches (from Tiedemann). ¼

For the detailed description of this figure see p. 404; 6, renal arteries; 6', 6', suprarenal arteries arising from the aorta; other suprarenal arteries are seen proceeding

Fig. 287.



from the inferior phrenic ; 7, placed on the abdominal aorta below the origin of the spermatic arteries ; 7, 7′, lower down the same arteries descending on the psoas muscles and crossing the ureters, that on the left side entering the internal inguinal aperture along with the vas deferens (i) ; 8, inferior mesenteric artery ; 9, lumbar arteries ; 9′, the lowest lumbar artery rising in this instance from the middle sacral (1′) ; 10, 10′, right and left common iliac arteries ; 11, 11, placed between the external and internal iliac arteries on each side ; 12, left epigastric artery ; 13, circumflex iliac artery.

In the female, the *ovarian* arteries, corresponding to the spermatic arteries in the male, are shorter than these vessels, and do not pass out of the abdominal cavity. The origin, direction, and connections of the ovarian artery in the first part of its course are the same as in the male; but at the margin of the pelvis it inclines inwards, and running tortuously between the layers of the broad ligament of the uterus, is guided to the attached margin of the ovary, which it supplies with branches. Some small offsets can be also traced along the round ligament into the inguinal canal, and others along the Fallopian tube: one, continuing inwards towards the uterus, joins with the uterine artery.

In the young fœtus the spermatic and ovarian arteries are short, as the testes and ovaries are at first placed close to the kidneys, but the arteries become lengthened as these organs descend to their ultimate positions.

Peculiarities.—The *spermatic* arteries occasionally arise by a common trunk. Two spermatic arteries are not unfrequently met with on one side; both of these usually arise from the aorta, though sometimes one is a branch from the renal artery. A case has occurred of three arteries on one side,—two from the aorta and the third from the renal.

B.—PARIETAL BRANCHES OF THE ABDOMINAL AORTA.

I. INFERIOR PHRENIC ARTERIES.

The phrenic arteries are two small vessels, which spring from the aorta close together on a level with the under surface of the diaphragm. These arteries are, however, somewhat irregular in their origin. When they arise separately from each other, which is by no means a constant arrangement, one is frequently derived from the cœliac artery close to the origin, and the other from the aorta immediately above. They soon diverge from each other, and passing across the crura of the diaphragm, incline upwards and outwards upon its under surface; the artery of the left side passing behind the œsophagus, whilst that of the right side passes behind the vena cava. Before reaching the central tendon of the diaphragm, each of the arteries divides into two branches, of which one runs forwards towards the anterior margin of the thorax, and anastomoses with the musculo-phrenic branch of the internal mammary artery, while the other pursues a transverse direction towards the side of the thorax, and communicates with the terminations of the intercostal arteries.

Branches.—Each phrenic artery gives small branches (superior capsular) to the suprarenal capsule of its own side; the left artery sends some branches to the œsophagus, whilst the artery of the right side gives off small vessels, which reach the termination of the vena cava. Small offsets descend to the liver between the layers of the peritoneum.

Peculiarities.—The *phrenic* arteries are found to vary greatly in their mode of origin, but these deviations seem to have little influence on their course and distribution. In the first place they may arise either separately, or by a common trunk: and it would appear that the latter mode of origin is nearly as frequent as the former.

When the two arteries are joined at their origin, the common trunk arises most frequently from the aorta; though, sometimes, it springs from the cœliac axis.

When arising separately, the phrenic arteries are given off sometimes from the aorta, more frequently from the cœliac axis, and occasionally from the renal; but it most commonly happens that the artery of the right side is derived from one, and that of the left side from another of these sources. An additional phrenic artery (derived from the left hepatic) has been met with.

In only one out of thirty-six cases observed by R. Quain did the phrenic arteries arise in the mode ordinarily described; viz., as two separate vessels from the abdominal aorta. (Op. cit. p. 417.)

II. LUMBAR ARTERIES.

The lumbar arteries resemble the intercostal arteries, not only in their mode of origin, but also in a great measure in the manner of their distribution. They arise from the back part of the aorta, and are usually four in number on each side. They pass outwards, each resting on the body of the corresponding lumbar vertebra, from the first to the fourth, and soon dip deeply under the psoas muscle. The two upper arteries are likewise under the pillars of the diaphragm; and those on the right side are covered by the vena cava. At the interval between the transverse processes, each lumbar artery divides into a *dorsal* and an *abdominal* branch.

Branches.—(*a*) The *abdominal* branch of each lumbar artery runs outwards behind the quadratus lumborum,—the lowest of these branches not unfrequently in front of that muscle. Continuing outwards between the abdominal muscles, the artery ramifies in their substance, and maintains communications with branches of the epigastric and internal mammary in front, with the terminal branches of the intercostals above, and with those of the ilio-lumbar and circumflex iliac arteries below.

(*b*) The *dorsal* branch of each lumbar artery, like the corresponding branch of the intercostal arteries, gives off, immediately after its origin, an offset, named *spinal*, which enters the spinal canal. The dorsal branch then, proceeding backwards with the posterior primary branch of the corresponding lumbar nerve between the transverse processes of the vertebræ, divides into smaller vessels, which are distributed to the muscles and integuments of the back.

(*c*) The *spinal branch* enters the spinal canal through the intervertebral foramen, and, having given an offset which runs along the nerves to the dura mater and cauda equina, it communicates with the other spinal arteries, and divides into two branches, which are distributed to the bones in the following manner:—one curves upwards on the back part of the body of the vertebra above, near to the root of the pedicle, whilst the other descends in a similar manner on the vertebra below; and each communicates with a corresponding branch from the neighbouring spinal artery. As this arrangement prevails on both sides and throughout the whole length of the spine, there is formed a double series of arterial arches behind the bodies of the vertebræ, the convexities of which are turned towards each other. From the arches on opposite sides offsets are directed inwards at intervals to reinforce a median longitudinal vessel, which extends along the spine like the single artery on the front of the spinal cord. The arches are moreover joined together across the bodies of the vertebræ by transverse branches.

From this interlacement of vessels, numerous ramifications are distributed to the periosteum and the bones.

Peculiarities.—The *lumbar* arteries of opposite sides, instead of taking their origin separately from the aorta, occasionally commence by a common trunk, whose branches pass out laterally, and continue their course in the ordinary way. Two arteries of the same side are sometimes conjoined at their origin. On the last lumbar vertebra, the place of a lumbar artery is often taken by a branch from the middle sacral artery, and the ilio-lumbar compensates for the absence of the lumbar vessel amongst the muscles.

MINUTE ANASTOMOSES OF THE VISCERAL AND PARIETAL BRANCHES OF THE ABDOMINAL AORTA.

The existence of minute anastomoses between some of the visceral branches of the abdominal aorta and those supplying the walls of the cavity has been recognised by several anatomists, and various examples have been noticed in the previous description. These communications have recently been more distinctly proved and their nature elucidated by W. Turner in a series of experimental injections, made with a view to their detection. ("Brit. and For. Med. Chirug. Review," July, 1863.)

These anastomoses constitute a well-marked vascular plexus, situated in the sub-peritoneal tissue, whence Turner proposes to call them the *sub-peritoneal arterial plexus.* It occupies the lumbar region from the diaphragm downwards into the iliac regions and pelvis, and establishes communication between the parietal vessels and those of the viscera, chiefly, though not exclusively, through branches of the arteries of those viscera which are situated behind the peritoneum. It belongs to the renal and suprarenal arteries, those of the pancreas and duodenum, the cæcum, and the ascending and descending parts of the colon. It extends also to the vessels of the rectum, and to the spermatic arteries in their descent through the abdomen, and into the inguinal canal and scrotum.

In all these situations it was found that the injected material (coloured gelatine) when thrown into the vessels of the viscus, so as to fill them completely, extended through the subperitoneal plexus in various ways, so as to reach one or other set of parietal vessels, such as the lumbar, ilio-lumbar, circumflex iliac, lower intercostal and epigastric arteries; and in the pelvis, the middle and lateral sacral arteries; and in the scrotum, the superficial pudic and perineal arteries.

The more direct inosculations of the hæmorrhoidal arteries on the rectum with the inferior hæmorrhoidal branches of the pudic artery are well known, and the importance of these and other similar anastomoses, as well as the more extensive and minute anastomosing plexus investigated by Turner, is obvious, with reference not merely to the nutrition of the subperitoneal tissue, but also to the debated question of the influence exerted by local superficial blood-letting on the state of the vessels of the deeper viscera.

III. MIDDLE SACRAL ARTERY.

The middle sacral artery, the last of the branches of the abdominal aorta, is a small vessel of about the size of a crowquill, which arises from the extremity of the aorta just at the bifurcation. From this point the artery proceeds downwards upon the last lumbar vertebra and over the middle of the sacrum, as far as the coccyx, where it forms small arches of anastomosis with the lateral sacral arteries.

Branches.—From its anterior surface some small branches come forward within the fold of the meso-rectum, and ramify upon the posterior surface of the intestine; and on each side others spread out upon the sacrum, and anastomose with the lateral sacral arteries, occasionally sending small offsets into the anterior sacral foramina.

The middle sacral artery sometimes deviates a little to the side, and proceeds, not from the bifurcation of the aorta, but from one of the common iliac arteries, usually from that of the left side. This artery represents the caudal prolongation of the aorta of animals.

COMMON ILIAC ARTERIES.

The common iliac arteries, commencing at the bifurcation of the aorta, pass downwards and outwards, diverging from each other, and divide opposite the lumbo-sacral articulation into the internal and external iliac arteries.

The common iliac arteries measure usually about two inches in length. Both are covered by the peritoneum and the intestines, and are crossed by the ureters near their point of division, as well as by the branches of the sympathetic nerve which are directed towards the hypogastric plexus. They rest on the bodies of the vertebræ, and come into contact with the psoas muscles.

The common iliac artery of the right side is separated from the front of the last lumbar vertebra, the two common iliac veins being interposed. The artery of the left side is crossed by the branches of the inferior mesenteric vessels.

Relation to Veins.—The left iliac vein, supported on the last lumbar

vertebra, lies to the inner side of, and below the left artery. On the right side there are three veins in proximity to the artery; the right iliac vein lying behind the lower part of the vessel, the left iliac vein crossing behind it, and the vena cava resulting from the union of the two others being on the right side of the artery at the upper end.

Peculiarities.—*The place of origin* of the common iliac arteries coincides with that of the bifurcation of the aorta (p. 406).

Fig. 288.

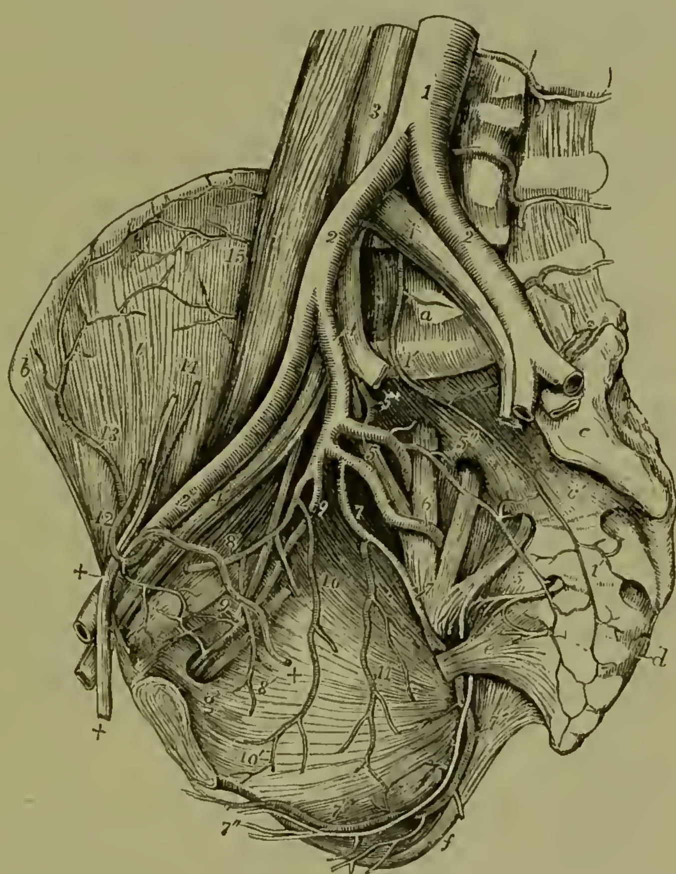


Fig. 288.—View of the right side of a Male Pelvis dissected to show the external and internal Iliac Arteries and their branches. $\frac{1}{3}$

The viscera of the pelvis have been removed as well as the internal iliac veins: the larger nerves have been retained. *a*, body of the fifth lumbar vertebra; *b*, anterior and superior spine of the right ilium; *c*, left auricular surface of the sacrum; *c′*, third piece of the sacrum; *d*, first piece of the coccyx; *e*, short sacro-sciatic ligament; *f*, tuberosity of the ischium covered internally by the great sacro-sciatic ligament; *g*, obturator foramen; *i*, iliacus muscle; 1, lower part of the abdominal aorta; 1′, middle sacral artery; 2, 2, common iliac arteries; 2′, right external iliac; 3, lower part of the vena cava inferior; 4, 4, common iliac veins; the number on the right points by a line to the right internal iliac artery; 4′, right external iliac vein; 5, placed on the ilio-lumbar nervous trunk, points to the posterior division of the internal iliac artery giving off the gluteal; 5′, ilio-lumbar artery; 5″, lateral sacral artery with branches passing into the anterior sacral foramina; 6, placed on the anterior division of the first sacral nerve, points to the sciatic artery coming from the anterior division of the internal iliac; 7, pudic artery; 7′, the same artery passing behind the spine of the ischium, and proceeding within the ischium and obturator internus muscle, accompanied by the pudic nerve towards the perinæum; towards *f*, inferior hæmorrhoidal branches are given off; 7″, superficial perineal artery and nerve; 8, hypogastric artery, with the obliterated remains of the umbilical artery cut short, and 8′, superior vesical branches rising from it; 9, obturator artery with the corresponding nerve and vein; 9′, the pubic twigs which anastomose with descending twigs of the epigastric artery, and from which, by the enlargement of one of them, the aberrant obturator artery may proceed; 10, inferior vesical; 11, middle hæmorrhoidal vessels rising in this instance from the pudic; 12, epigastric artery winding to the inside of +, +, the vas deferens and spermatic cord; 13, circumflex iliac artery; 14, spermatic artery and vein divided superiorly; 15, twigs of the ilio-lumbar artery proceeding to anastomose with the circumflex iliac.

The place of division of these arteries is subject to great variety. In two thirds of a large number of cases, it ranged between the middle of the last lumbar vertebra and the upper margin of the sacrum; in one case out of eight it was above, and in one case out of six it was below that space. Most frequently the left artery was found to divide lower down than the right. (R. Quain.)

The length varies in most instances between an inch and a half and three inches, but it has been seen in some rare cases less than half an inch, and as long as four inches and a half. In one instance, recorded by Cruveilhier, ("Anat. descript." v. iii. p. 186,) the right common iliac artery was wanting, and the internal and external vessels of that side arose as distinct branches from the aorta.

Branches.—The common iliac artery often gives off a small unnamed branch to the lymphatic glands, the ureter or the psoas muscle, and sometimes even a larger branch —a renal artery, a lumbar, or the ilio-lumbar.

INTERNAL ILIAC ARTERY.

The internal iliac artery (hypogastrica, pelvica) extends from the bifurcation of the common iliac artery towards the sacro-sciatic foramen, near which it divides into branches. It is usually about an inch and a half in length, and is smaller than the external iliac in the adult, but the reverse in the fœtus. At its origin, the artery lies near the inner border of the psoas muscle; lower down, it rests against part of the pyriform muscle. Behind it are situated the internal iliac vein, and the communicating branch which passes from the lumbar to the sacral plexus of nerves: in front it is crossed by the ureter, which separates it from the peritoneum.

Branches.—The branches of the internal iliac artery, though constant, and regular in their general distribution, vary much in their origin. They arise, in most instances, from two principal divisions of the parent trunk, of which one is anterior to the other. From the anterior division arise the superior vesical (connected with the pervious portion of the fœtal hypogastric artery), the inferior vesical, middle hæmorrhoidal, obturator, internal pudic, and sciatic arteries, and also, in the female, the uterine and the vaginal arteries. The posterior division gives off the gluteal, the ilio-lumbar, and the lateral sacral arteries.

Peculiarities.—*Length.*—The internal iliac artery has been found as short as half an inch, and sometimes as long as three inches, but it is not often less than an inch in length. An instance has been observed in which this vessel was absent, and its branches were derived from a bend of the external iliac artery down into the pelvis (Preparation in Univ. Coll. Mus., London). The lengths of the common iliac and internal iliac arteries bear an inverse proportion to each other—the internal iliac being long when the common iliac is short, and *vice versâ.* Moreover, when the common iliac is short, the internal iliac (arising higher than usual) is placed for some distance above the brim of the pelvis, and descends by the side of the external iliac to reach that cavity.

The *place of division* of the internal iliac into its branches varies between the upper margin of the sacrum and the upper border of the sacro-sciatic foramen.

Branches.—Sometimes all the branches of the internal iliac artery arise without the previous separation of that vessel into two portions.

In more than a fourth of R. Quain's cases a branch, corresponding usually to the ilio-lumbar artery, arose before the subdivision of the main trunk.

Hypogastric Artery.—*In the fœtus*, the internal iliac artery, retaining almost the full size of the common iliac, curves forwards from that artery to the side of the urinary bladder, and ascends on the anterior wall of the abdomen to the umbilicus. There the vessels of opposite sides come in

contact with one another and with the umbilical vein, and coiling spirally round that vein in the umbilical cord, they proceed to the placenta. To that part of the artery which is placed within the abdomen, the term *hypogastric* is applied; the remaining portion, passing onwards through the umbilicus to the placenta, being the proper *umbilical* artery. After the cessation of the placental circulation at birth, the two hypogastric arteries become impervious from the side of the bladder upwards to the umbilicus, and are converted into fibrous cords. These two cords, which extend from the sides of the bladder to behind the umbilicus, being shorter than the part of the peritoneum on which they rest, cause a fold of the serous membrane to project inwards; and thus are formed two fossæ (fossæ of the peritoneum) on each side of the abdomen, in one or other of which the projection of a direct inguinal hernia takes place. The part of the artery intervening between the origin of the vessel and the side of the bladder remains pervious, although proportionally much reduced in size, and forms the trunk of the superior vesical artery.

BRANCHES OF THE INTERNAL ILIAC ARTERY.

I. VESICAL ARTERIES.

The urinary bladder receives several arteries, amongst which, however, may be specially recognised two principal branches, a superior and an inferior vesical artery.

The *superior vesical* artery is, at its commencement, that part of the hypogastric artery in the fœtus which remains pervious after the changes that take place subsequently to birth. It extends from the anterior division of the internal iliac to the side of the bladder.

Branches.—(*a*) It distributes numerous branches to the upper part and sides of the bladder.

(*b*) The *artery of the vas deferens*, or the *deferent artery*, arising from one of the lowest of these, is a slender artery which reaches the vas deferens, and accompanies that duct in its course through the spermatic cord to the back of the testicle, where it anastomoses with the spermatic artery.

(*c*) Other small branches ramify on the lower end of the ureter.

The *inferior vesical* artery (vesico-prostatic), derived usually from the anterior division of the internal iliac, is directed downwards to the lower part of the bladder, where it ends in branches which are distributed to the base of the bladder, to the side of the prostate, and to the vesiculæ seminales. One offset, to be presently described, descends upon the rectum.

The branches upon the prostate communicate more or less freely upon that body with the corresponding vessels of the opposite side, and, according to Haller, with the perineal arteries likewise.

Small twigs of this vessel also run towards the subpubic arch, and in instances of deficient pudic arteries replace one or more of their branches, as will be more fully noticed under those arteries.

Besides the superior and inferior vesical arteries, other smaller branches will be found to reach the bladder, and usually one slender vessel which is distributed particularly to the under surface of the vesiculæ seminales.

Middle hæmorrhoidal artery.—This branch is usually supplied to the rectum by the inferior vesical artery, but sometimes proceeds from other

Fig. 289.

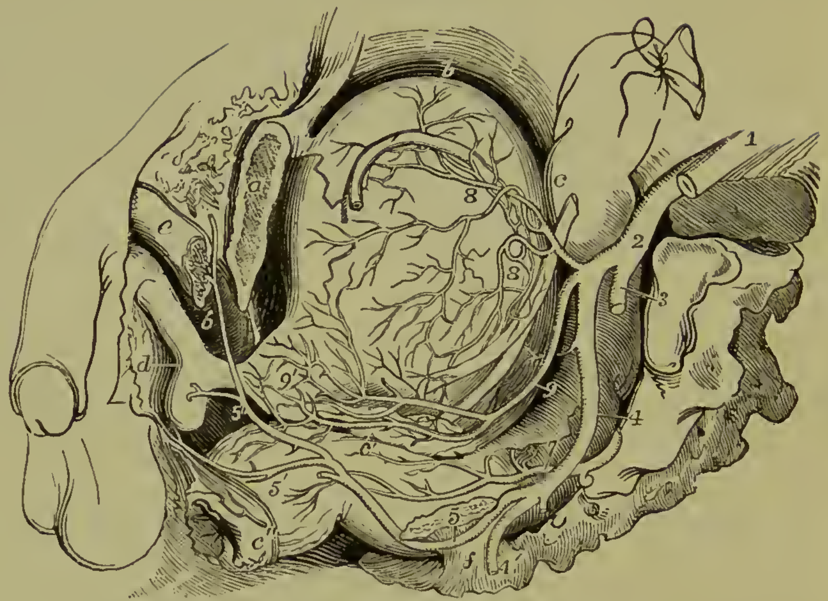


FIG. 289.—VIEW OF THE VISCERA OF THE MALE PELVIS FROM THE LEFT SIDE, SHOWING THE VESICAL AND PUDIC ARTERIES (from R. Quain). $\frac{1}{3}$

a, the os pubis divided a little to the left of the symphysis; *b*, placed close to the upper part of the urinary bladder, upon which lies the vas deferens; *c*, placed on the upper part of the rectum, near the left ureter; *c′*, at the junction of the middle and lower parts of the rectum points to the vesicula seminalis; *c″*, the anus; *d*, the urethral bulb; *e*, the crus penis divided; *f*, the short sacro-sciatic ligament attached to the spine of the ischium; 1, common iliac artery; 2, internal iliac artery; 3, gluteal artery cut short; 4, common trunk of the sciatic and pudic arteries; 4′, sciatic artery cut as it is passing out of the great sacro-sciatic foramen; 5, placed on the divided surface of the ischium near the spine, points to the pudic artery as it is about to re-enter the pelvis by the lesser sacro-sciatic foramen; 5′, the superficial perineal branches of the pudic; 5″, the pudic artery, proceeding to give the artery of the bulb, and passing on to give 6, the artery of the crus penis and the dorsal artery of the penis; 7, placed on the middle part of the rectum, points to the descending branches of the superior hæmorrhoidal artery; 8, the superior and middle vesical arteries; 9, the inferior vesical artery, of considerable size in this instance, giving branches to the bladder, the vesicula seminalis, the rectum (middle hæmorrhoidal), and 9′, to the prostate gland.

sources. It anastomoses with the branches of the other hæmorrhoidal arteries.

II. UTERINE AND VAGINAL ARTERIES.

The uterine artery is directed downwards from the anterior division of the internal iliac artery towards the neck of the uterus. Insinuating itself between the layers of the broad ligament, it passes upwards on the side of the uterus, pursuing an exceedingly tortuous course, and sends off numerous branches, which enter the substance of that organ.

This artery supplies small branches to the bladder and the ureter; and, near its termination, communicates with an offset directed inwards from the ovarian artery.

Vaginal artery.—The vagina derives its arteries principally from a branch which corresponds with the inferior vesical in the male. The *vaginal* artery descends and ramifies upon the vagina, at the same time sending some

offsets to the lower part of the bladder over the neck, and others to the contiguous part of the rectum.

Fig. 290.

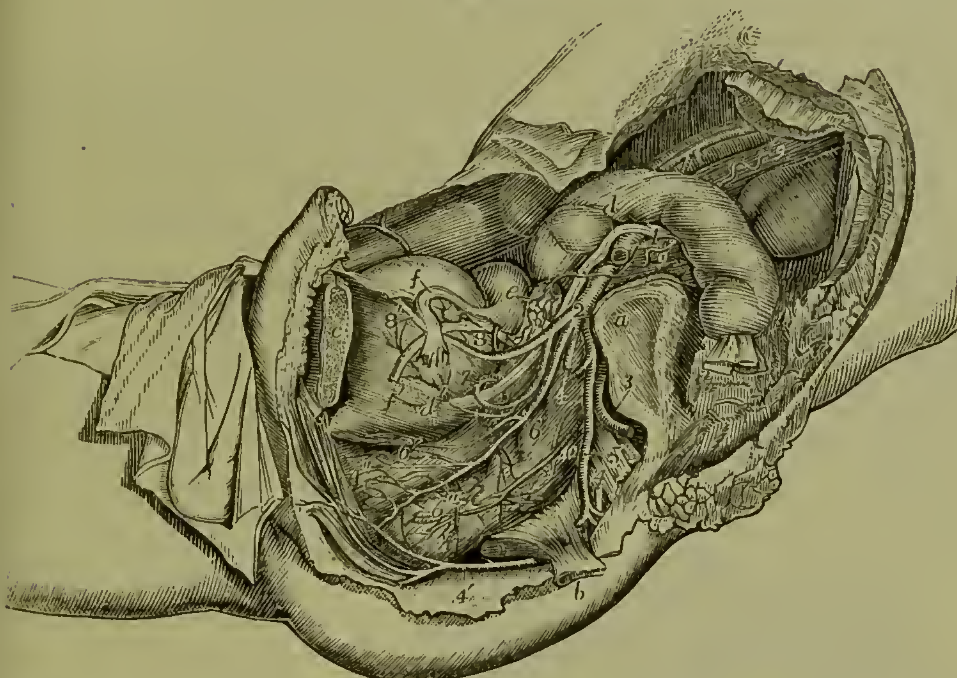


Fig. 290.—View of the distribution of the arteries to the Viscera of the Female Pelvis, as seen on the removal of the left Os Innominatum, &c. (from R. Quain). $\frac{1}{4}$

a, the left auricular surface of the sacrum ; *b*, the spine of the ischium with the short sacro-sciatic ligament ; *c*, the os pubis cut a little to the left of the symphysis ; *d*, placed upon the sigmoid part of the colon, and *d'* on the lower part of the urinary bladder, point to the ureter ; *e*, on the upper part of the body of the uterus, points by a line to the left ovary ; *f*, on the upper part of the bladder, points to the left Fallopian tube ; *f'*, round ligament of the uterus ; 1, left external iliac artery cut short ; 2, left internal iliac artery ; 3, gluteal artery cut short ; 4, 4, left pudic artery from which a part has been removed ; 4', the same artery after it has re-entered the pelvis proceeding towards the muscles of the perinæum, clitoris, &c. ; 5, placed on the sacral nerves, points to the sciatic artery ; 6, 6', inferior vesical and vaginal arteries ; 6'', branches from these to the rectum ; 7, uterine artery much coiled ; 8, the superior vesical, and 8', the remains of the hypogastric artery ; 9, 9, the left ovarian artery, descending from the aorta, and emerging from below the peritoneum ; 10, the superior hæmorrhoidal artery spreading over the left side of the rectum.

III. OBTURATOR ARTERY.

The obturator artery is in most instances derived from the internal iliac ; it usually arises from the anterior portion of that vessel, but not unfrequently from its posterior division. The artery is directed forwards along the inside of the pelvis to reach the groove at the upper part of the thyroid foramen. By this aperture it passes out of the pelvis, and immediately divides into its terminal branches. In its course through the pelvis, the artery is placed between the pelvic fascia and the peritoneum, a little below the obturator nerve. Beneath the pubes it lies with its accompanying vein and nerve in an oblique canal, formed partly by a groove in the bone, and partly by fibrous tissue, after passing through which it divides imme-

diately into an external and an internal branch, which are deeply placed behind the external obturator muscle.

Branches.—(*a*) *Within the pelvis*, besides others of smaller size, the obturator artery often supplies a branch to the iliac fossa and muscle, and one which runs backwards upon the urinary bladder.

(*b*) *Anastomotic* vessels, which may be called *pubic*, are given off by the obturator artery as it is about to escape from the pelvis: these vessels ramify on the back of the pubes, and communicate behind the bone and the attachments of the abdominal muscles, with small offsets from the epigastric artery. These anastomosing branches lie to the inner side of the crural ring.

(*c*) The *internal terminal* branch curves inwards beneath the obturator externus, close to the inner margin of the thyroid foramen, and furnishes branches to the obturator muscles, the gracilis, and the adductor muscles.

(*d*) The *external terminal* branch has a similar arrangement near the outer margin of the thyroid foramen; it descends as far as the ischial tuberosity, and supplies the obturator muscles, and the upper ends of the long muscles which are attached to that tuberosity. This branch usually sends off a small artery, which enters the hip-joint through the cotyloid notch, and ramifies in the synovial fatty tissue, and along the round ligament as far as the head of the femur.

Fig. 291.

A

B

Fig. 291, A. and B.—Views of the Left Wall of the Pelvis, with the attached abdominal muscles from the inside, showing different positions of the Aberrant Obturator Arteries (from R. Quain). $\frac{1}{4}$

In A, a case is represented in which the aberrant artery passes to the outside of a femoral hernial protrusion; in B, an instance is shown in which it surrounds the neck of the sac.

a, posterior surface of the rectus muscle; *b*, iliacus internus muscle; *c*, symphysis pubis; *d*, obturator membrane; *e*, placed on the fascia transversalis, points to the vas deferens passing through the internal inguinal aperture; *f*, the testicle; +, the neck of a femoral hernial sac; 1, the external iliac artery; 2, the external iliac vein; below 2, the obturator nerve; 3, the epigastric artery; 4, aberrant obturator artery, arising from the epigastric.

The two terminal branches of the obturator artery communicate with each other near the lower margin of the obturator ligament, and anastomose with branches of the internal circumflex artery. The external branch also communicates with offsets from the sciatic artery near the tuber ischii.

Peculiarities.—The obturator artery frequently has its origin transferred to the

commencement of the epigastric artery, and sometimes to the external iliac at its termination.

In 361 cases observed by R. Quain, the origin of the obturator artery varied as follows:—In the proportion of 2 cases out of 3, it arose from the internal iliac: in 1 case out of 3½, from the epigastric: in a very small number of cases (about 1 in 72), it arose by two roots from both the above-named vessels; and in about the same proportion, from the external iliac artery.

Sometimes the obturator artery arises from the epigastric on both sides of the same body, but, in the majority of instances, this mode of origin of the vessel is met with only on one side.

When the obturator artery arises from the epigastric it turns backwards into the pelvis to reach the canal at the upper part of the thyroid foramen; and in this course it is necessarily close to the crural ring, the opening situated at the inner side of the external iliac vein, through which hernial protrusions descend from the abdomen into the thigh. In the greater number of instances the artery springs from near the root of the epigastric, and is directed backwards close to the iliac vein, and therefore lies to the outer side of the femoral ring; but in other instances, arising from the epigastric artery higher up, it occasionally crosses over the ring, and curves to its inner side. It is when it takes this last course that the obturator artery is liable to be wounded in the operation for dividing the stricture in a femoral hernia.

The anastomosis which normally exists between the obturator artery and the epigastric explains the nature of the change which takes place when the origin of the obturator artery is transferred from the one place to the other. In such cases one of the anastomosing vessels may be supposed to have become enlarged, and the posterior or proper root of the obturator artery to have remained undeveloped or to have been obliterated in a proportionate degree.

IV. PUDIC ARTERY.

The pudic or internal pudic artery is a branch of considerable size (smaller in the female than in the male), which is distributed to the external generative organs. The following description of this artery has reference to its arrangement in the male; its distribution in the female will be noticed separately.

The pudic artery arises from the anterior division of the internal iliac, sometimes by a trunk common to it and the sciatic artery. Proceeding downwards, it passes superficially or posteriorly close to the ischial spine, thus emerging from the pelvis along with the sciatic artery, through the great sacro-sciatic foramen. Continuing in a uniformly curved course, it re-enters the pelvis by the small sacro-sciatic foramen, immediately below the ischial spine, and passes forward on the inner side of the tuber ischii, in the substance of the obturator fascia.

Distant at first from the lower margin of the ischial tuberosity an inch or an inch and a half, it approaches the surface on the inner margin of the pubic arch, and lies subjacent to the triangular ligament or superficial layer of the subpubic fascia. Finally, piercing this fascia, it divides below the subpubic arch into the dorsal artery of the penis and the artery of the corpus cavernosum.

In the first part of its course, whilst within the pelvis, the pudic artery lies to the outer side of the rectum, and in front of the pyriformis muscle and the sacral nerves. Thence onwards it is accompanied by the pudic nerve and vein. On the ischial spine it is covered by the gluteus maximus muscle close to its origin. In the obturator fascia it lies external to the ischio-rectal fossa and internal to the obturator internus muscle, and beneath the triangular ligament it is crossed by the deep transverse perineal muscle.

Branches.—(*a*) The *inferior* or *external hæmorrhoidal* arteries, two or three in number, incline inwards from the pudic artery as it passes outside the ischio-rectal fossa above the tuber ischii. These small vessels run across the ischio-rectal fossa, through the fat in that space, and are distributed to the sphincter and levator ani muscles, and to the parts surrounding the anus.

Fig. 292.

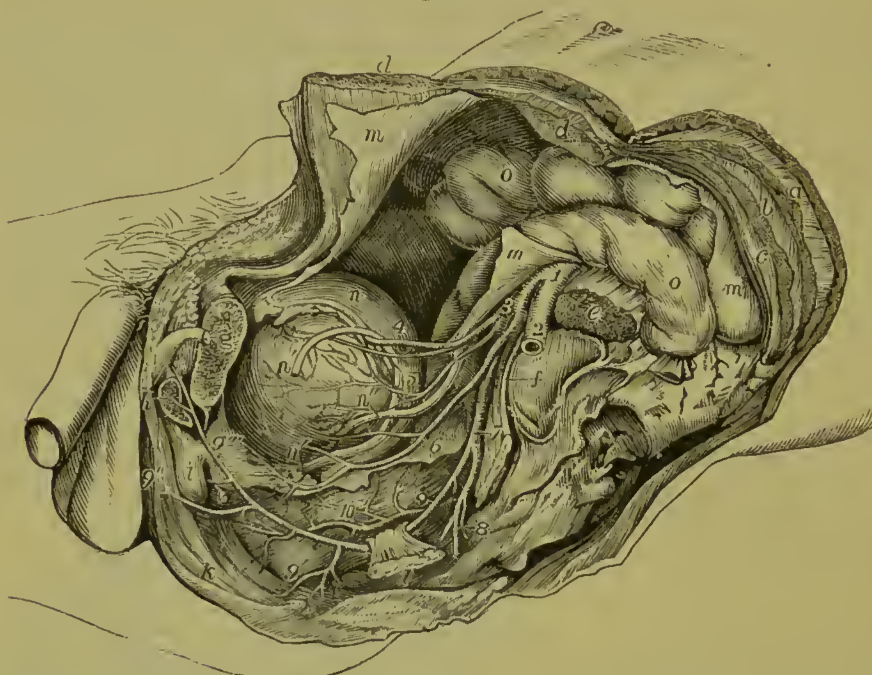


Fig. 292.—View of the Distribution of the Arteries to the Viscera of the Male Pelvis, as seen on the removal of the Left Os Innominatum, &c. (from R. Quain). $\frac{1}{4}$

a, left external oblique muscle of the abdomen divided ; *b*, internal oblique ; *c*, transversalis ; *d*, *d*, the parts of the rectus muscle divided and separated ; *e*, psoas magnus muscle divided ; *f*, placed on the left auricular surface of the sacrum, points by a line to the sacral plexus of nerves ; *g*, placed on the os pubis, sawn through a little to the left of the symphysis, points to the divided spermatic cord ; *h*, the cut root of the crus penis ; *i*, the bulb of the urethra ; *k*, elliptical sphincter ani muscle ; *l*, a portion of the ischium near the spinous process, to which is attached the short sacro-sciatic ligament ; *m*, the parietal peritoneum ; *n*, the upper part of the urinary bladder ; *n'*, *n'*, the left vas deferens descending towards the vesicula seminalis ; *n''*, the left ureter ; *o*, the intestines ; 1, the common iliac at the place of its division into external and internal iliac arteries ; 2, left external iliac artery ; 3, internal iliac ; 4, obliterated hypogastric artery, over which the vas deferens is seen passing, with the superior vesical artery below it ; 5, middle vesical artery ; 6, inferior vesical artery, giving branches to the bladder, and descending on the prostate gland and to the back of the pubes ; 7, placed on the sacral plexus, points to the common trunk of the pudic and sciatic arteries ; close above 7, the gluteal artery is seen cut short ; 8, sciatic artery cut short as it is escaping from the pelvis ; 9, placed on the rectum, points to the pudic artery as it is about to pass behind the spine of the ischium ; 9', on the lower part of the rectum, points to the inferior hæmorrhoidal branches ; 9'', on the perinæum, indicates the superficial perineal branches ; 9''', placed on the prostate gland, marks the pudic artery as it gives off the arteries of the bulb and of the crus penis ; 10, placed on the middle part of the rectum, indicates the superior hæmorrhoidal arteries as they descend upon that viscus.

(*b*) The *superficial perineal* artery, a long, slender, but regular vessel, supplies the scrotum and the upper part of the perinæum. Given off from the pudic artery in front of the hæmorrhoidal branches, it turns upwards parallel with the pubic arch, crosses the transverse muscle of the perinæum, and runs forwards under cover of the

superficial fascia, between the erector penis and accelerator urinæ muscles, supplying both. In this course the artery gradually becomes superficial, and is finally distributed to the skin of the scrotum and the dartos. It not unfrequently gives off the following branch.

Fig. 293.

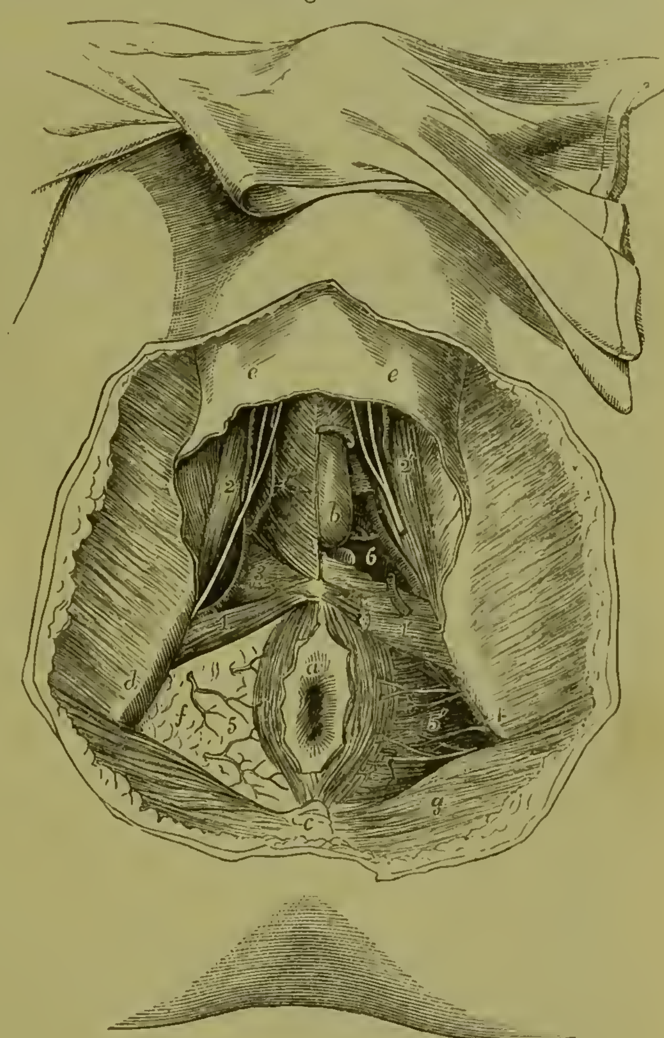


Fig. 293. — Dissection of the Perinæum in a young Male Subject, showing the Blood-vessels, &c. ½

This drawing is made from a preparation upon a modification of the plan of R. Quain's 61st and 62nd Plates. The right side shows a superficial, the left a deeper view.

a, the anus, with a part of the integument surrounding it; *b*, left half of the bulb of the urethra exposed by the removal of a part of the bulbo-cavernosus muscle; *c*, coccyx; *d*, right tuberosity of the ischium; *e*, *e*, the anterior part of the superficial perineal fascia passing forward upon the scrotum, and removed from the surface of the muscles and its reflections into the deep fascia; *f*, right ischio-rectal fossa from which the fat and fascia have not been removed; *g*, gluteus maximus muscle; 1, placed on the right transversus perinæi muscle, points to the superficial perineal artery as it emerges in front (in this case) of the muscle; 1′, placed on the left side on the surface of the triangular ligament near its reflection into the superficial fascia, points to the superficial perineal artery cut short; 2, on the right ischio-cavernosus muscle, points to the superficial perineal arteries and nerves passing forward; 2′, the same on the left side, the vessels and nerves having been divided there; 3, on the triangular ligament of the right side, points to the transverse perineal branch of the superficial perineal artery; 4, on the left tuberosity of the ischium, points to the pudic artery deep in the ischio-rectal fossa; 5, 5′, the inferior hæmorrhoidal branches of the pudic arteries and nerves; 6, on the left side, placed in a recess from which the triangular ligament or anterior layer of the sub-pubic fascia has been removed to show the continuation of the pudic artery, its branch to the bulb, and one of Cowper's glands.

(*c*) The *transverse perineal* artery, a very small vessel, arises either from the pudic artery, or from the superficial perineal, near the transversus perinæi muscle. It lies across the perinæum, and terminates in small branches which are distributed to the transverse muscle, and to the parts between the anus and the bulb of the urethra.

(*d*) The *artery* of the *bulb*, is, surgically considered, an important vessel. It is very

short; arising from the pudic between the layers of the sub-pubic fascia, and passing transversely inwards, this artery reaches the bulb a little in front of the central point of the perinæum, and ramifies in the erectile tissue. It gives a branch to Cowper's gland.

(*e*) The *artery* of the *corpus cavernosum* (profunda penis), one of the terminal branches of the internal pudic, runs a short distance between the crus penis and the ramus of the pubes, and then continuing forward penetrates the crus, and ramifies in the corpus cavernosum.

(*f*) The *dorsal artery of the penis* runs between the crus and the pubic symphysis: having pierced the suspensory ligament, it continues along the dorsum of the penis immediately beneath the skin, and parallel with the dorsal vein, as well as with the corresponding artery of the opposite side. It supplies the integument of the penis, and the fibrous sheath of the corpus cavernosum, anastomosing with the deep arteries; and, near the corona glandis, divides into branches, which supply the glans and the prepuce.

Peculiarities.—*Origin.* The pudic artery is sometimes small, or it is defective in one or two, or even three of its usual branches, which, in those circumstances, are supplied by a supplemental vessel, the "*accessory pudic.*" The defect most frequently met with is that in which the pudic ends as the artery of the bulb, whilst the arteries of the corpus cavernosum and the dorsum of the penis are derived from the accessory pudic. But all the three arteries of the penis may be supplied by the accessory pudic, the pudic itself ending as the superficial perineal. A single accessory pudic has been seen to supply both cavernous arteries, whilst the pudic of the right side gave both dorsal arteries. On the other hand, cases have occurred in which only a single branch was furnished by the accessory artery, either to take the place of an ordinary branch altogether wanting, or to aid one of the branches which was diminutive in size.

The *accessory pudic*, the occasional artery above alluded to, generally arises from the pudic itself, before the passage of that vessel from the sacro-sciatic foramen, and descends within the pelvis, and along the lower part of the urinary bladder. It lies on the upper part of the prostate gland, or it may be, for a short space, likewise on the posterior margin, and then proceeding forwards above the membranous part of the urethra, reaches the perinæum, by piercing the fascia of the sub-pubic arch.

The accessory pudic sometimes arises with the other branches from the internal iliac, and is not unfrequently connected with the prostatic or other branch of the inferior vesical artery. A vessel having a similar distribution may spring from the external iliac, through an irregular obturator, or through the epigastric artery.

Branches.—Artery of the bulb. This vessel is sometimes small, sometimes wanting on one side, and occasionally it is double. But a more important deviation from the common condition is one sometimes met with, in which the vessel, arising earlier, and crossing the perinæum farther back than usual, reaches the bulb from behind. In such a case there is considerable risk of dividing the artery in performing the lateral operation for stone. On the other hand, when this small vessel arises from an accessory pudic artery, it lies more forward than usual, and out of danger in case of operation.

The *dorsal* artery of the penis has been observed to arise from the deep femoral artery and to pass obliquely upwards and inwards to reach the root of the penis. Tiedemann gives a drawing of this variety.

The *pudic artery in the female.*—In the female this vessel is much smaller than in the male. Its course is similar, and it gives the following *branches:*

The *superficial perineal* branch is distributed to the labia pudendi. The *artery of the bulb* supplies the mass of erectile tissue above and at the sides of the entrance of the vagina, named the bulb of the vagina. Whilst the two terminal branches, corresponding to the artery of the corpus cavernosum and the dorsal artery of the penis, are distributed to the clitoris, and are named the *profunda* and *dorsal* arteries.

V. SCIATIC ARTERY.

The sciatic artery, the largest branch of the internal iliac trunk, excepting the gluteal, is distributed to the muscles on the back of the pelvis. It descends upon the pelvic surface of the pyriformis muscle and the sacral plexus of nerves ; and turning backwards beneath the border of that muscle, it passes between it and the superior gemellus, and thus escapes from the pelvis, along with the great sciatic nerve and the pudic artery, at the lower part of the great sciatic foramen. Outside the pelvis, this artery lies in the interval between the tuber ischii and the great trochanter, covered by the gluteus maximus.

Branches.—The sciatic artery gives off several branches to the external rotator muscles of the thigh, on which it lies, and to the great gluteus by which it is concealed. Two others have received special names, viz., the following :—

(*a*) The *coccygeal*, inclines inwards, and piercing the great sacro-sciatic ligament, reaches the posterior surface of the coccyx, and ramifies in the fat and skin about that bone.

(*b*) The other named branch, *comes nervi ischiadici*, runs downwards, accompanying the sciatic nerve, along which it sends a slender vessel.

Some of the branches of this artery are distributed to the capsule of the hip-joint; whilst others, after supplying the contiguous muscles, anastomose with the gluteal, the internal circumflex, and the superior perforating arteries in the upper part of the long flexor muscles of the thigh.

VI. GLUTEAL ARTERY.

The gluteal artery, the largest branch of the internal iliac, is distributed to the muscles on the outside of the pelvis. It inclines downwards to the great sacro-sciatic foramen, and escaping from the cavity of the pelvis, between the contiguous borders of the middle gluteal and the pyriform muscles, divides immediately into a superficial and a deep branch.

Branches.—(*a*) The *superficial* branch running between the gluteus maximus and gluteus medius, divides into ramifications which are most copiously distributed to the gluteus maximus, and anastomose with the sciatic and posterior sacral arteries.

(*b*) The *deep* branch, situated between the gluteus medius and gluteus minimus, runs in an arched direction forwards, and divides into two other branches. One of these, the superior branch, follows the upper border of the gluteus minimus beneath the middle gluteal muscle and the tensor of the fascia lata, towards the anterior iliac spine, and, after having freely supplied the muscles between which it passes, anastomoses with the circumflex iliac and the ascending branches of the external circumflex arteries. The second or inferior branch descends towards the great trochanter, supplies the gluteal muscles, and anastomoses with the external circumflex and the sciatic arteries.

(*c*) A *nutrient* branch enters the hip-bone at the place where the artery emerges from the pelvis.

VII. ILIO-LUMBAR ARTERY.

The ilio-lumbar artery resembles in a great measure one of the lumbar arteries. It passes outwards beneath the psoas muscle and the external iliac vessels, to reach the margin of the iliac fossa, where it separates into a *lumbar* and an *iliac* division. The first of these ramifies in the psoas and quadratus muscles, communicating with the last lumbar artery, and furnishing branches to the vertebral canal. The second or *iliac* division, turning downwards and outwards, either in the iliacus muscle or between it and the bone, anastomoses with the circumflex iliac artery, and even with the external branches of the epigastric.

Peculiarities.—The ilio-lumbar artery sometimes arises from the internal iliac, above the division of that trunk; and more rarely from the common iliac. The iliac and lumbar portions sometimes arise separately from the parent trunk.

Fig. 294.

Fig. 294.—Arteries of the Back of the Pelvis and Upper Part of the Thigh (from Tiedemann). $\frac{1}{4}$

a, crest of the ilium; *b*, tuberosity of the ischium and lower attachment of the great sacro-sciatic ligament; *c*, great trochanter; *d*, integument round the anus; *e*, great sciatic nerve; 1, trunk of the gluteal artery as it issues from the great sacro-sciatic foramen, the superficial branches cut short, the deep arch seen passing round on the upper part of the gluteus minimus muscle; 2, placed on the great sacro-sciatic ligament, points to the pudic artery at the place where it winds over the back of the spine of the ischium; 2′, the continuation of the artery towards the perinæum on the inside of the tuberosity and ramus of the ischium; 3, 3, the sciatic artery, the upper figure placed on the pyriformis muscle, the lower on the great sciatic nerve; 4, 4′, first perforating artery passing through the upper part of the great adductor muscle and anastomosing with the posterior branch of the internal circumflex artery, which appears between the quadratus and the adductor muscles; 5 and 6, part of the second and third perforating arteries.

When the lowest of the lumbar arteries is wanting it is replaced by a branch from the ilio-lumbar, which is increased in size, and by a small offset from the middle sacral artery.

VIII. LATERAL SACRAL ARTERIES.

The *lateral sacral* arteries are usually two in number on each side, though occasionally they are united into one. The two arteries arise close together from the posterior division of the internal iliac. One is distributed upon the upper, and the other upon the lower part of the sacrum.

Both arteries pass downwards, at the same time inclining somewhat inwards, in front of the pyriform muscle and the sacral nerves, which they supply with twigs, and reach the inner side of the anterior sacral foramina. Continuing to descend, the lower one approaches the middle line, and anastomoses with the middle sacral artery.

Dorsal Branches.—The lateral sacral arteries give off a series of branches which enter the anterior sacral foramina. Each of these, after having furnished within the foramen a spinal branch, which ramifies on the bones and membranes in the interior of the sacral canal, escapes by the corresponding posterior sacral foramen, and is distributed upon the dorsal surface of the sacrum.

EXTERNAL ILIAC ARTERY.

The external of the two arteries resulting from the division of the common iliac forms a large continuous trunk, which extends downwards in the limb as far as the lower border of the popliteus muscle, but, for convenience of description, it is named in successive parts of its course external iliac, femoral, and popliteal.

The external iliac artery, larger than the internal iliac artery, is placed within the abdomen, and extends from the division of the common iliac to the lower border of Poupart's ligament, where the vessel enters the thigh, and is named femoral. Descending obliquely outwards, its course through the abdominal cavity may be marked by a line drawn from the left side of the umbilicus to a point midway between the anterior superior spinous process of the ilium and the symphysis pubis. This line would also indicate the direction of the common iliac artery, from which the external iliac is directly continued.

The vessel is covered by the peritoneum and intestines. It lies along the upper margin of the true pelvis, resting upon the inner border of the psoas muscle. The artery, however, is separated from the muscle by the fascia iliaca, to which it is bound, together with the external iliac vein, by the sub-peritoneal tissue.

Fig 295.

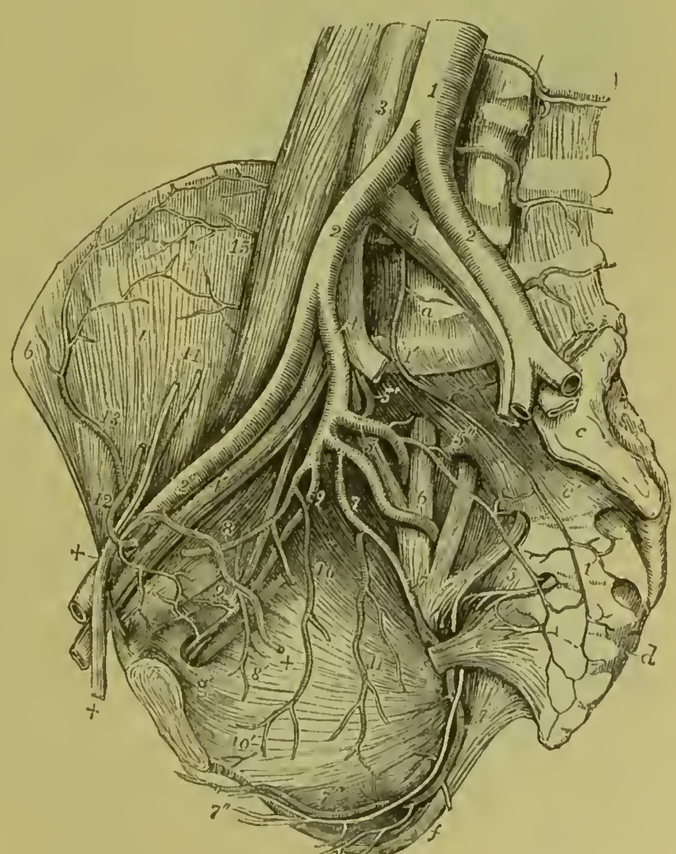


Fig. 295.—View of the principal Arteries and their Divisions on the Right Side of a Male Pelvis.

For the detailed description of this figure see Fig. 288, p. 419.

2′, the right external iliac artery, accompanied by the corresponding vein 4′, passing below into the femoral vessels under Poupart's ligament; 12, epigastric artery winding to the inside of +, +, the spermatic cord; the epigastric artery is cut short superiorly; 13, circumflex iliac artery anastomosing with 15, branches of the ilio-lumbar; 14, spermatic artery and vein descending to join the spermatic cord; +, within the pelvis, the vas deferens descending from the cord towards the bladder.

Relation to Veins, &c.—The external iliac vein lies at first behind the artery with an inclination to the inner side; but as both vessels approach Poupart's ligament at the fore part of the pelvis, the vein is on the same plane with the artery and quite to the inner side, being borne forwards by the bone. At a short distance from its lower end the artery is crossed by the circumflex iliac vein.

Fig. 296.

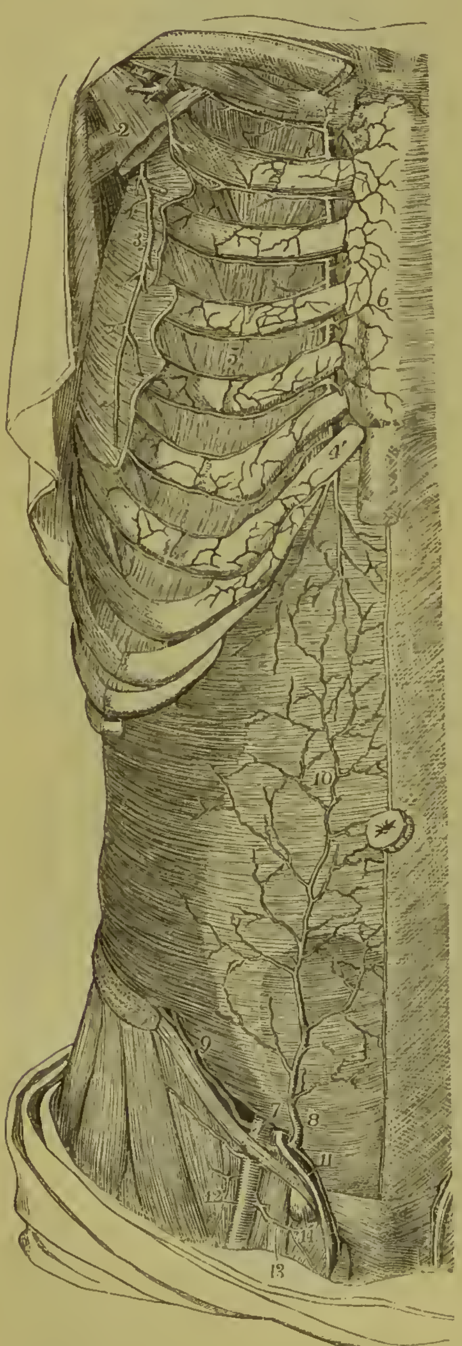


Fig. 296.—View of the Distribution and Anastomosis of the Epigastric and Internal Mammary Arteries (from Tiedemann). $\frac{1}{4}$

For the detailed description of this figure, see Fig. 265, p. 375.

7, placed on the transversalis muscle above the internal inguinal aperture, points to the last part of the external iliac artery at the place where it gives origin to 8, the epigastric and 9, the circumflex iliac artery; 10, anastomosis of the epigastric artery and the abdominal branch of the internal mammary in and behind the rectus muscle; 11, the spermatic cord receiving the external spermatic branch from the epigastric artery; 12, femoral artery; 13, femoral vein; 14, a lymphatic gland closing the femoral ring.

Large *lymphatic glands* are found resting upon the front and inner side of the vessel; and the spermatic vessels descend upon it near its termination. A branch of the *genito-crural nerve* crosses it just above Poupart's ligament.

Branches. — The external iliac artery supplies some small branches to the psoas muscle and the neighbouring lymphatic glands, and, close to its termination, two other branches of considerable size, named the epigastric and the circumflex iliac, which are distributed to the walls of the abdomen.

1. The epigastric artery (inferior epigastric) arises from the forepart of the external iliac artery, usually a few lines above Poupart's ligament. It first inclines downwards, so as to get on a level with the ligament, and then passes obliquely upwards and inwards between the fascia transversalis and the peritoneum, to reach the rectus muscle of the abdomen. It ascends almost vertically behind the rectus,

and rising within the sheath, is placed between it and the muscle, and terminates at some distance above the umbilicus in offsets which ramify in the substance of the muscle and anastomose with the terminal branches of the internal mammary and inferior intercostal arteries.

The epigastric artery is accompanied by two *veins*, which unite into a single trunk before ending in the external iliac vein.

In its course upwards from Poupart's ligament to the rectus muscle, the artery passes close to the inner side of the internal abdominal ring; and the vas deferens, entering through the ring, turns behind the artery in descending into the pelvis.

Branches.—These are small, but numerous.

(*a*) The *cremasteric* artery, a slender branch, accompanies the spermatic cord, and supplying the cremaster muscle and other coverings of the cord, anastomoses with the spermatic artery.

(*b*) Several *muscular* branches arise from each side of the epigastric artery, ramify in the rectus muscle, and communicate with the branches of the lumbar and circumflex iliac arteries.

(*c*) *Superficial* branches perforate the abdominal muscles, and join beneath the skin with branches of the superficial epigastric artery.

(*d*) The *pubic* is a small branch, which ramifies behind the pubes, and communicates by means of one or more descending twigs with a similar branch from the obturator artery.

Fig. 297.

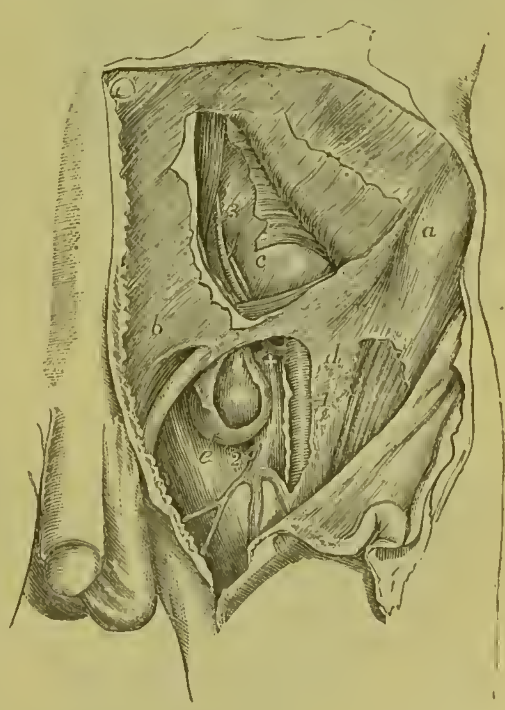


Fig. 297.—View of the relation of the Vessels of the Groin to a Femoral Hernia, &c. (from R. Quain). ¼

In the upper part of the figure a portion of the flat muscles of the abdomen has been removed, displaying in part the transversalis fascia and peritoneal lining of the abdomen; in the lower the fascia lata of the thigh is in part removed and the sheath of the femoral vessels opened: the sac of the femoral hernial tumour has also been opened.

a, anterior superior spinous process of the ilium; *b*, aponeurosis of the external oblique muscle above the external inguinal aperture; *c*, the abdominal peritoneum and fascia transversalis; *d*, the iliac portion of the fascia lata near the saphenic opening; *e*, sac of a femoral hernia; 1, points to the femoral artery; 2, femoral vein at the place where it is joined by the saphena vein; 3, epigastric artery and vein passing up towards the back of the rectus muscle; +, placed upon the upper part of the femoral vein close below the common trunk of the epigastric and an aberrant obturator artery; the latter artery is seen in this case to pass close to the vein and between it and the neck of the hernial tumour.

2. The circumflex iliac artery, smaller than the preceding vessel, arises from the outer side of the iliac artery near Poupart's ligament, and is

directed outwards behind that band to the anterior superior iliac spine. Following thence the crest of the hip-bone, the artery gives branches to the iliacus muscle, furnishes others which are distributed to the abdominal muscles, and anastomoses with the ilio-lumbar artery. In its course outwards this artery lies in front of the transversalis fascia, at the junction of this with the fascia iliaca.

Two *veins* accompany the circumflex iliac artery; these unite below into a single vessel, which crosses the external iliac artery about an inch above Poupart's ligament, and enters the external iliac vein.

The *muscular* branch is given off near the iliac crest, and ascends on the fore-part of the abdomen between the transversalis and internal oblique muscles: having supplied those muscles, it anastomoses with the lumbar and epigastric arteries. This branch varies much in size, and is occasionally replaced by several smaller muscular offsets.

Peculiarities.—*Size.*—In those rare cases in which the principal blood-vessel of the lower limb is continued from the internal iliac (p. 441), the external iliac artery is correspondingly diminished, and ends in the muscles of the front of the thigh, taking the place of the profunda.

Branches.—The usual *number* of two principal branches of the external iliac artery may be increased by the separation of the circumflex iliac into two branches, or by the addition of a branch usually derived from another source, such as the internal circumflex artery of the thigh or the obturator artery.

The *epigastric* artery occasionally arises higher than usual, as at an inch and a half, or even two inches and a half, above Poupart's ligament; and it has been seen to arise below that ligament from the femoral, or from the deep femoral artery. The epigastric frequently furnishes the obturator artery; and two examples are recorded in which the epigastric artery arose from an obturator furnished by the internal iliac artery. (Monro, "Morbid Anatomy of the Human Gullet," &c., p. 427. A. K. Hesselbach, "Die sicherste Art des Bruchschnittes," &c.) In a single instance the epigastric artery was represented by two branches, one arising from the external iliac, and the other from the internal iliac artery. (Lauth, in "Velpeau's Médecine Opératoire," v. ii p. 452.) Some combinations of the epigastric with the internal circumflex, or with the circumflex iliac, or with both those vessels, have been noticed.

The *circumflex iliac* artery sometimes deviates from its ordinary position,—arising at a distance not exceeding an inch above Poupart's ligament. Deviations in the opposite direction are more rarely met with; it has in a few cases been observed to arise below the ligament, from the femoral artery.

FEMORAL ARTERY.

The femoral artery is that portion of the artery of the lower limb which lies in the upper two-thirds of the thigh,—its limits being marked above by Poupart's ligament, and below by the opening in the great adductor muscle, after passing through which the artery receives the name popliteal.

A general indication of the direction of the femoral artery over the fore-part and inner side of the thigh is given by a line reaching from a point midway between the anterior superior iliac spine and the symphysis of the pubes to the inner side of the internal condyle of the femur. At the upper part of the thigh, it lies along the middle of a depression between the muscles covering the femur on the outer side, and the adductor muscles on the inner side of the limb, and which is known by the name of Scarpa's triangle. In this situation the beating of the artery may be felt, and the circulation through the vessel may be most easily controlled by pressure. Below the upper third of the thigh it is crossed by the upper and inner

Fig. 298.

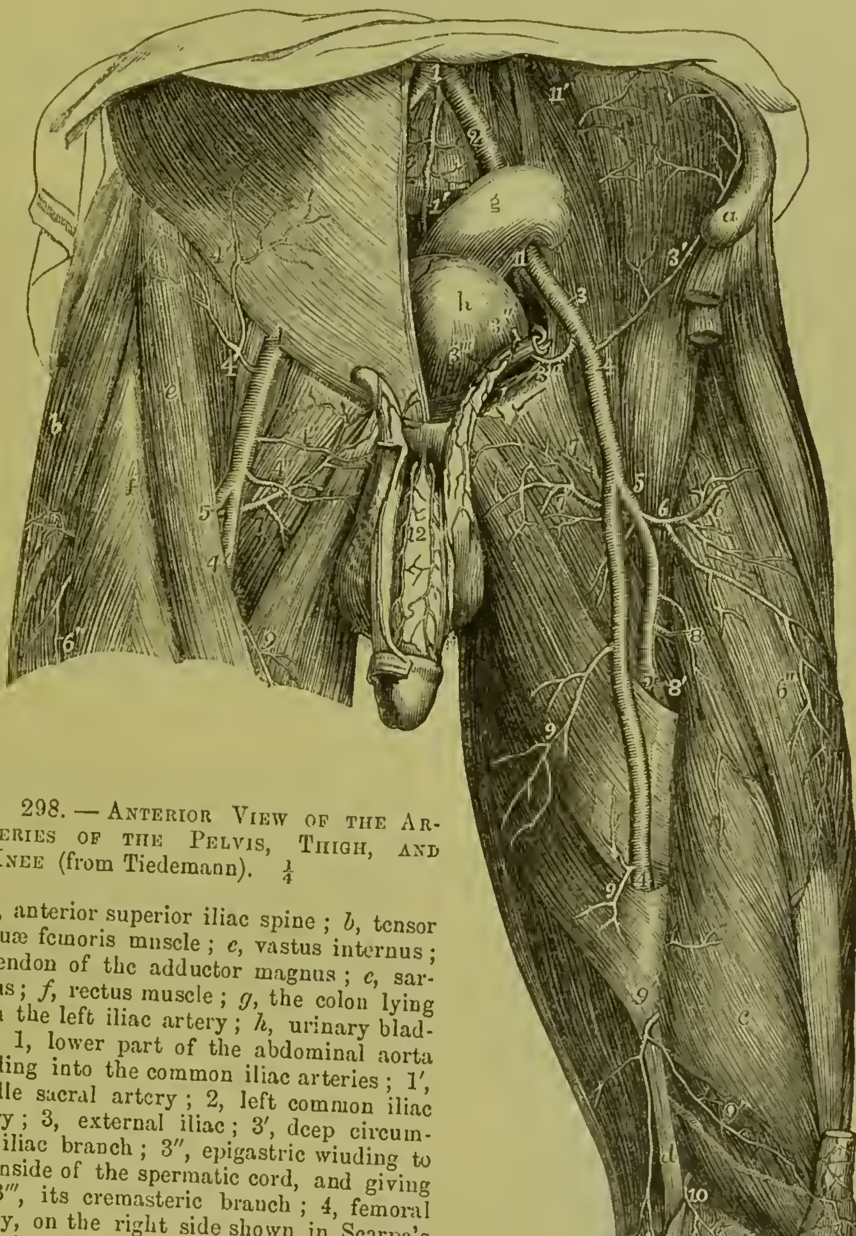


Fig. 298. — Anterior View of the Arteries of the Pelvis, Thigh, and Knee (from Tiedemann). $\frac{1}{4}$

a, anterior superior iliac spine; *b*, tensor vaginæ femoris muscle; *c*, vastus internus; *d*, tendon of the adductor magnus; *e*, sartorius; *f*, rectus muscle; *g*, the colon lying upon the left iliac artery; *h*, urinary bladder; 1, lower part of the abdominal aorta dividing into the common iliac arteries; 1′, middle sacral artery; 2, left common iliac artery; 3, external iliac; 3′, deep circumflex iliac branch; 3″, epigastric winding to the inside of the spermatic cord, and giving off 3‴, its cremasteric branch; 4, femoral artery, on the right side shown in Scarpa's triangle, on the left exposed as far as Hunter's canal; 4′, superficial circumflex iliac and epigastric of the right side; 4″, superficial pudic and inguinal branches; 5, profunda femoris artery, descending on the left side behind the adductor longus; 6, external circumflex; 6′, its ascending or gluteal branches; 6″, its descending branches; 7, 7′, internal circumflex artery; 8, superior perforating; 8′, second perforating branch; 9, 9, muscular branches of the femoral artery; 9′, anastomotic branch; 10, internal superior articular branch of the popliteal; 10′, inferior branch.

border of the sartorius muscle which forms the outer wall of the triangle, and which conceals the vessel in the remainder of its course. In the first

part of its course the femoral artery is covered only by the skin and fascia lata, and by the sheath which invests both the artery and vein, viz., the crural sheath (p. 293). In the lower part of its course it is deeply placed, being covered not only by the sartorius muscle, but by a dense stratum of fibrous structure, which stretches across from the tendons of the long and great adductors to the vastus internus muscle, and encloses the space called *Hunter's canal*, in which the vessels lie.

The artery rests successively upon the following parts. First, upon the psoas muscle, by which it is separated from the margin of the pelvis and the capsule of the hip-joint; next, it is placed in front of the pectineus muscle, the deep femoral artery and vein being interposed; afterwards, it lies upon the long adductor muscle; and lastly, upon the tendon of the great adductor, the femoral vein being placed between the tendon and the artery. At the lower part of its course, it has immediately on its outer side the vastus internus muscle, which intervenes between it and the inner side of the femur.

At the groin the artery, after having passed over the margin of the pelvis, is placed slightly in front of or internal to the head of the femur; and at its lower end, the vessel lies close to the inner side of the shaft of the bone; but in the intervening space, in consequence of the projection of the neck and shaft of the femur outwards, while the artery holds a straight course, it is separated from the bone by a considerable interval.

Fig. 299.

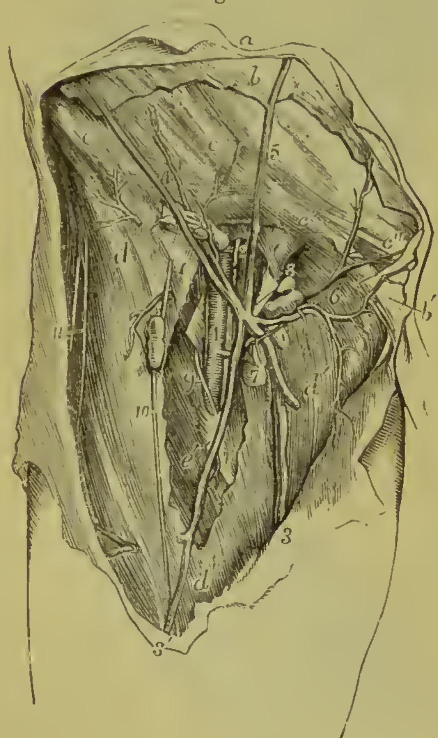


Fig. 299.—View of the Femoral Vessels, with their smaller Superficial Branches in the Right Groin (from R. Quain). $\frac{1}{4}$

a, the integument of the abdomen; *b*, the superficial abdominal fascia; *b′*, the part descending on the spermatic cord; *c*, *c*, the aponeurosis of the external oblique muscle; *c′*, the same near the external abdominal ring; *c″*, the inner pillar of the ring; *d*, the iliac part of the fascia lata; *d′*, the pubic part; *e*, *e*, the sheath of the femoral vessels laid open, the upper letter is immediately over the crural aperture; *e′*, placed on the sartorius muscle partially exposed, points to the margin of the saphenic opening; 1, femoral artery, having the femoral vein 2, to its inner side, and the septum of the sheath shown between the two vessels; 3, the principal saphenous vein; 3′, its anterior branches; 4, the superficial circumflex iliac vein and arterial branches to the glands of the groin; 5, the superficial epigastric vein; 6, the external pudic arteries and veins; 7 to 8, some of the lower inguinal glands receiving twigs from the vessels; 9, internal, 10, middle, and 11, external cutaneous nerves.

Relation to Veins.—The femoral vein is very close to the artery, both being enclosed in the same sheath, and separated from each other only by a thin partition of fibrous membrane. At the groin the vein lies in the same plane as the artery, and on the inner side; but gradually inclining backwards, it is placed behind it, at the

lower end of Scarpa's space, and afterwards gets somewhat to the outer side. The deep femoral vein, near its termination, crosses behind the femoral artery ; and the long saphenous vein, as it ascends on the fore part of the limb, lies to the inner side ; but it not unfrequently happens that a superficial vein of considerable size ascends for some space directly over the artery.

Relation to Nerves.—At the groin the *anterior crural nerve* lies a little to the outer side of the femoral artery (about a quarter of an inch), separated from the vessel by some fibres of the psoas muscle and by the sheath and fascia. Lower down in the thigh, the *long saphenous* nerve accompanies the artery until this vessel perforates the adductor magnus. There are likewise small cutaneous nerves which cross the artery.

Branches.—The femoral artery gives off the following branches :—some small and superficial, which are distributed to the integument and glands of the groin and ramify on the lower part of the abdomen, viz., the external pudic (superior and inferior), the superficial epigastric, and the superficial circumflex iliac ; the great nutrient artery of the muscles of the thigh, named the deep femoral ; several muscular branches ; and lastly, the anastomotic artery, which descends on the inner side of the knee-joint.

The portion of the femoral artery extending from its commencement to the origin of the deep femoral, a part varying from an inch to two inches in length, is sometimes distinguished by surgical writers as the *common femoral*, and described as dividing into the *superficial* and *deep* femoral arteries.

I. Superficial inguinal branches.—The *external pudic arteries* arise either separately or by a common trunk from the inner side of the femoral artery. The *superior*, the more superficial branch, courses upwards and inwards to the pubic spine, crosses the external abdominal ring, passing in the male over the spermatic cord, and is distributed to the integuments on the lower part of the abdomen, and on the external organs of generation. The *inferior* branch, more deeply seated, extends inwards, resting on the pectineus muscle, and covered by the fascia lata, which it pierces on reaching the inner border of the thigh, and is distributed to the scrotum in the male, or to the labium in the female, its branches inosculating with those of the superficial perineal artery.

The *superficial epigastric* artery, arising from the femoral vessel, about half an inch below Poupart's ligament, passes forwards through the fascia lata, and runs upwards on the abdomen in the superficial fascia covering the external oblique muscle. Its branches, ascending nearly as high as the umbilicus, anastomose with superficial branches of the epigastric and internal mammary arteries.

The *superficial circumflex iliac* artery runs outwards in the direction of Poupart's ligament towards the iliac spine, across the psoas and iliacus muscles : to both of these it gives small branches, as also some others which pierce the fascia lata ; it is distributed to the integument.

All the preceding arteries give small branches to the lymphatic glands in the groin.

II. The deep femoral artery—(profunda femoris) the principal nutritious vessel of the thigh, is an artery of considerable calibre, being nearly equal in size to the continuation of the femoral after the origin of this great branch. It usually arises from the outer and back part of the femoral artery, between an inch and two inches below Poupart's ligament. At its

commencement, it inclines outwards in front of the iliacus muscle, to such an extent as to be visible for a short distance external to the femoral artery; it then runs downwards and backwards behind that vessel, and passing behind the long adductor muscle, between it and the great adductor, near their femoral attachments, divides into terminal branches, which pierce the great adductor, and ramify in the muscles at the back and outer part of the thigh.

Fig. 300.

Fig. 300.—Deep View of the Femoral Artery and its Branches on the Left Side (from R. Quain). $\frac{1}{4}$

The sartorius muscle has been removed in part, so as to expose the artery in the middle third of the thigh. *a*, the anterior superior iliac spine; *b*, the aponeurosis of the external oblique muscle near the outer abdominal ring, from which the spermatic cord is seen descending towards the scrotum; *c*, the upper part of the rectus femoris muscle; *d*, adductor longus; *e*, fibrous sheath of Hunter's canal covering the artery; 1, femoral artery; 1′, femoral vein divided and tied close below Poupart's ligament; 2, profunda femoris artery; 3, anterior crural nerves; 4, internal circumflex branch; 5, superficial pudic branches; 6, external circumflex branch, with its ascending transverse and descending branches separating from it; 6′, twigs to the rectus muscle; 7, branches to the vastus internus muscle; 8, and 9, some of the muscular branches of the femoral.

This artery lies successively in front of the iliacus, pectineus, adductor brevis and adductor magnus muscles. The femoral and profunda veins and the long adductor muscle are interposed between it and the femoral trunk.

The named branches of the deep femoral artery are the external and the internal circumflex, and the perforating arteries.

1. The *external circumflex* artery, a branch of considerable size, arises from the outer side of the profunda near its origin, and passing outwards for a short distance beneath the sartorius and rectus muscles, and through the divisions of the anterior crural nerve, divides into three sets of branches.

(*a*) *Transverse* branches pass outwards over the crureus muscle, pierce the vastus externus, so as to get between it and the femur, just below the great trochanter, and

reach the back part of the thigh, where they anastomose with the internal circumflex and the perforating branches of the deep femoral, and with the gluteal and sciatic branches of the internal iliac.

(*b*) *Ascending* branches, directed upwards beneath the sartorius and rectus, and afterwards under the tensor muscle of the fascia lata, communicate with the terminal branches of the gluteal, and with some of the external descending branches of the circumflex iliac artery.

(*c*) *Descending* branches incline outwards and downwards upon the extensor muscles of the knee, covered by the rectus muscle. They are usually three or four in number, some being of considerable size; most of them are distributed to the muscles on the fore-part of the thigh, but one or two can be traced beneath the vastus externus muscle as far as the knee, where they anastomose with the arterial branches surrounding that joint.

2. The *internal circumflex* artery, smaller than the external circumflex, arises close to that branch from the inner and hinder part of the deep femoral artery, and is directed backwards between the pectineus and the psoas muscle to the inner side of the femur, so that only a small part of it can be seen without displacing these muscles. On reaching the tendon of the external obturator, along which the vessel passes to the back of the thigh, it divides into two principal branches.

(*a*) The *ascending* branch is distributed partly to the adductor brevis and gracilis, and partly to the external obturator muscle, near which it anastomoses with the obturator artery.

(*b*) The *transverse* branch passes backwards above the small trochanter, and appears on the back of the limb, between the quadratus femoris and great adductor muscles, where it supplies the hamstring muscles, and anastomoses with the sciatic artery and with the superior perforating branches of the deep femoral artery.

(*c*) An *articular* vessel, arising from the transverse branch opposite the hip-joint, enters the joint through the notch in the acetabulum, beneath the transverse ligament, and supplies the adipose tissue and the synovial membrane in that articulation. Some offsets are guided to the head of the femur by the round ligament. In some instances the articular branch is derived from the obturator artery; and sometimes the joint receives a branch from both sources.

3. The *perforating* arteries (perforantes) are branches which reach the back of the thigh by perforating the adductor brevis and adductor magnus muscles; they are four in number, including the terminal branch of the parent vessel.

(*a*) The *first perforating* artery passes backwards below the pectineus muscle, through the fibres of the adductor brevis and magnus, and is distributed to both these adductor muscles, to the biceps and great gluteal muscle, and communicates with the sciatic and internal circumflex arteries.

(*b*) The *second perforating* artery, considerably larger than the first, passes through the adductor brevis and magnus; after which it divides into ascending and descending branches, which ramify in the hamstring muscles, and communicate with the other perforating branches: an offset from it, named the *nutrient artery* of the femur, enters the medullary foramen of that bone.

(*c*) The *third perforating* artery pierces the adductor magnus muscle, below the insertion of the adductor longus, and is distributed in a manner similar to the second perforating artery.

(*d*) The *fourth perforating* artery, the termination of the deep femoral artery, passing backwards close to the linea aspera, is distributed to the short head of the biceps and to the other hamstring muscles, and communicates with branches of the popliteal artery, and with the lower perforating arteries.

III. Muscular branches of the femoral artery.—In its course along the thigh, the femoral artery gives off several branches to the contiguous

muscles. They vary in number from two to seven. They supply the sartorius and the vastus internus, with other muscles which are close to

Fig. 301.

Fig. 301.—Posterior View of the Arteries of the Pelvis, Thigh, and Popliteal Space (from Tiedemann). ¼.

a, the iliac crest ; *b*, the great sacro-sciatic ligament attached to the tuberosity of the ischium ; *c*, great trochanter; *d*, the integument close to the anus ; *e*, great sciatic nerve ; *f*, the line from this letter crosses the tendons of the inner hamstring muscles ; *g*, head of the fibula ; 1, gluteal artery ; 2, pudic ; 3, sciatic artery, giving its branches to the short external rotator muscles, to the sciatic nerve, and to the upper part of the long flexor muscles ; 4, first perforating artery ; 4′, its branches to the flexor muscles ; 5, branches of the second perforating ; 6, branches of the third perforating ; 7, popliteal artery, near this the origin of the superior muscular branches ; 8, placed on the tendon of the adductor magnus near the origin of the superior articular branches ; 9, the anastomosis of the external superior articular with other branches ; 10, the sural branches ; 11, the recurrent of the anterior tibial artery.

the femoral artery : their size appears to bear an inverse proportion to that of the descending branches of the external circumflex artery.

IV. Anastomotic artery.—Close to its termination the femoral artery gives off a branch, constant but of moderate size, named the *anastomotic artery* (*anastomotica magna*), which descends in the same line as the femoral artery itself (see fig. 298). Arising from that vessel when about to enter the popliteal space, it descends upon the tendon of the adductor magnus to the inner condyle of the femur, giving off several branches, and covered by some of the fibres of the vastus internus muscle ; it finally anastomoses with the

internal articular arteries, and with the recurrent branch of the anterior tibial artery.

(*a*) A *superficial* branch accompanies the saphenous nerve beneath the sartorius muscle to the integument on the inner side of the knee.

(*b*) The *external* branch, arising from the lower part of the vessel, crosses over the femur, supplies offsets to the knee-joint, and forms an arch a little above the articular surface, by anastomosing with the superior external articular artery.

Peculiarities of the Femoral Artery and Branches.—*Trunk.*—Four instances have been recorded of division of the femoral artery below the origin of the profunda into two vessels, which subsequently were reunited near the opening of the adductor magnus so as to form a single popliteal artery. In all these cases, the arrangement of the vessels appears to have been similar. To one of them (that first observed) special interest is attached, inasmuch as it was met with in a patient operated upon for popliteal aneurism. (This case was treated by Charles Bell, and recorded in "The London Medical and Physical Journal," vol. lvi. p. 134. London, 1826.)

The femoral artery is occasionally replaced at the back of the thigh by a trunk continuous with the internal iliac. Having passed from the pelvis through the large sacro-sciatic notch, this trunk accompanies the great sciatic nerve along the back of the thigh to the popliteal space, where its connections and termination become similar to those of the vessel presenting the usual arrangement. Four examples of this deviation from the common state of the blood-vessel have been recorded. Reference is made to these in a Paper in vol. 36 of the Medico-Chirurgical Transactions, giving an account of a specimen of remarkable deformity of the lower limbs of a man in whom the artery was so transposed on both sides.

Branches.—The *deep femoral* is occasionally given off from the inner side of the parent trunk, and more rarely from the back part of the vessel. Occasionally it arises at a distance of less than an inch, and sometimes of more than two inches, below Poupart's ligament. It was even found by Richard Quain arising, in one instance, above Poupart's ligament. and in another four inches below it; but in the latter instance the internal and external circumflex arteries did not arise from the profunda.

The *external circumflex* branch sometimes arises directly from the femoral artery; or it may be represented by two branches, of which, in most cases, one proceeds from the femoral, and one from the deep femoral: both branches, however, have been seen to arise from the deep femoral, and much more rarely, both from the femoral artery.

The *internal circumflex* branch may be transferred to the femoral artery above the origin of the profunda. Examples have also been met with in which the internal circumflex arose from the epigastric, from the circumflex iliac, or from the external iliac artery.

POPLITEAL ARTERY.

The popliteal artery, placed at the back of the knee-joint, extends along the lower third of the thigh and the upper part of the leg, reaching from the opening in the great adductor to the lower border of the popliteus muscle. It is continuous above with the femoral, and divides at the lower end into the anterior and posterior tibial arteries.

This artery at first inclines from the inner side of the limb to reach a point behind the middle of the knee-joint, and thence continues to descend vertically to its lower end. Lying deeply in its whole course, it is covered for some distance at its upper end by the semi-membranosus muscle; a little above the knee it is placed in the popliteal space; inferiorly it is covered for a considerable distance by the gastrocnemius muscle, and at its termination by the upper margin of the soleus muscle.

At first the artery lies close to the inner side of the femur; in descending,

it is separated by an interval from the flat or somewhat hollowed triangular surface at the lower end of the bone ; it then rests on the posterior ligament of the knee-joint, and afterwards on the popliteus muscle.

Relation to Veins.—The popliteal vein lies close to the artery, behind and somewhat to the outer side till near its termination, where it crosses the artery and is placed somewhat on the inner side. The vein is frequently double along the lower part of the artery, and, more rarely, also at the upper part. The short saphenous vein, ascending into the popliteal space over the gastrocnemius muscle, approaches the artery as it is about to terminate in the popliteal vein.

Relation to the Nerve.—The *internal popliteal* nerve lies at first to the outer side of the artery, but much nearer to the surface than the vessel : the nerve afterwards crosses over the artery, and is placed behind and to the inner side below the joint.

Branches.—The branches of the popliteal artery may be arranged in two sets, viz., the muscular and the articular.

1. The *muscular branches* are divided into a superior and an inferior group.

(*a*) The *superior* branches, three or four in number, are distributed to the lower ends of the hamstring muscles, and also to the vasti muscles, and anastomose with the perforating and articular arteries.

Fig. 302.

Fig. 302—View of the Popliteal Artery and its Branches in the Right Leg (from Tiedemann). ¼

a, biceps muscle ; *b*, semi-membranosus ; *c*, semi-tendinosus ; 1, the popliteal artery ; 2, 3, the superficial sural branches ; 4, the outer, 5, the inner superior articular branch ; 6, the superior muscular ; 7, the inferior muscular or deep sural branches.

(*b*) The *inferior muscular* branches, or *sural* arteries, usually two in number, and of considerable size, arise from the back of the popliteal artery, opposite the knee-joint, and enter, one the outer and the other the inner head of the gastrocnemius muscle, which they supply, as well as the fleshy part of the plantaris muscle.

Over the surface of the gastrocnemius will be found at each side, and in the middle of the limb, slender branches, which descend a considerable distance along the calf of the leg, and end in the integument. These small vessels (superficial sural) arise separately from the popliteal artery, or from some of its branches.

2. The *articular arteries.* Two of these pass off nearly at right angles from the popliteal artery, one to each side, above the flexure of the joint, whilst two have a similar arrangement below it, and a fifth passes from behind into the centre of the joint.

(*a*) The *upper internal articular* artery winds round the femur just above the inner condyle ; and, passing under the tendon of the great adductor and the vastus internus, divides into two branches : one of these, comparatively superficial, enters the substance of the vastus, and inosculates with the anastomotic branch of the femoral, and with the lower internal articular artery.

The other branch runs close to the femur, ramifies upon it, and also on the knee-joint, and communicates with the upper external articular artery.

(*b*) The *upper external articular* artery passes outwards a little above the outer condyle of the femur, under cover of the biceps muscle, and, after perforating the intermuscular septum, divides into a superficial and a deep branch. The latter, lying close upon the femur, spreads branches upon it and the articulation, and communicates with the preceding vessel, with the anastomotic of the femoral, and with the lower external articular artery; the superficial branch descends through the vastus to the patella, anastomosing with other branches and assisting in the supply of the joint.

(*c*) The *lower internal articular* artery passes downwards below the internal tuberosity of the tibia, lying between the bone and the internal lateral ligament; its branches ramify on the front and inner part of the joint, as far as the patella and its ligament.

(*d*) The *lower external articular* artery takes its course outwards, under cover of the outer head of the gastrocnemius in the first instance, and afterwards under the external lateral ligament of the knee and the tendon of the biceps muscle, passing above the head of the fibula. Having reached the fore part of the joint, it divides near the patella into branches, some of which communicate with the lower articular artery of the opposite side, and with the recurrent branch from the anterior tibial; whilst others ascend, and anastomose with the upper articular arteries.

In this manner the four articular branches form at the front and sides of the knee-joint a close network of vessels.

Fig. 303.

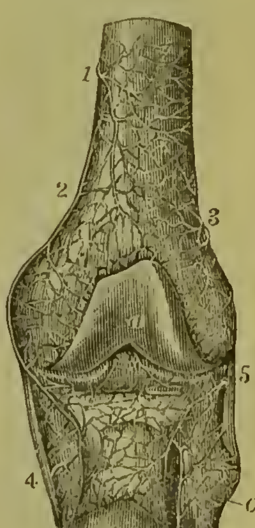


Fig. 303. — Anterior view of the Deep Arterial Branches surrounding the Knee-Joint and their Anastomoses (from Tiedemann). ¼

a, the patellar articular surface of the femur; *b*, the posterior or cartilaginous surface of the patella which, with the ligamentum patellæ, has been turned down; *c*, the head of the fibula; 1, and 2, branches of the internal superior articular branch of the popliteal ramifying on the periosteum, and anastomosing with the external superior articular branch 3, and with other arteries within and below the joint; 4, branches of the internal inferior articular; 5, external inferior articular; 6, recurrent of the anterior tibial artery.

(*e*) The *middle or azygos articular* artery, is a small branch which arises opposite the flexure of the joint, and, piercing the posterior ligament, supplies the crucial ligaments and other structures within the articulation.

Peculiarities.—Deviations from the ordinary condition of the popliteal artery are not frequently met with. The principal departure from the ordinary arrangement consists in its high division into terminal branches. Such an early division has been found to take place most frequently opposite the flexure of the knee-joint, and not higher.

In a few instances, the popliteal artery has been seen to divide into the anterior tibial and peroneal arteries—the posterior tibial being small or absent. In a single case, the popliteal artery was found to divide at once into three terminal vessels, viz., the peroneal and the anterior and posterior tibial arteries.

The *azygos articular* branch frequently arises from one of the other articular

branches, especially from the upper and external branch. There are sometimes several small middle articular branches.

POSTERIOR TIBIAL ARTERY.

The posterior tibial artery is situated along the back part of the leg, between the superficial and deep layers of muscles, and is firmly bound down to the deep muscles by the fascia which covers them. It extends from the lower border of the popliteus muscle, where it is continuous with the popliteal artery, down to the inner side of the calcaneum, where it terminates beneath the origin of the abductor pollicis muscle by dividing into the external and internal plantar arteries.

Placed at its origin opposite the interval between the tibia and fibula, it approaches the inner side of the leg as it descends, and lies behind tho tibia ; at its lower end it is placed midway between the inner malleolus and the prominence of the heel. Very deeply seated at the upper part, where it is covered by the fleshy portion of the gastrocnemius and soleus muscles, it becomes comparatively superficial towards the lower part, being there covered only by the integument and two layers of fascia, and by the annular ligament behind the inner malleolus. It lies successively upon the tibialis posticus, the flexor longus digitorum, and, at its lower end, directly on the tibia and the ankle-joint. Behind the ankle, the tendons of the tibialis posticus and flexor longus digitorum lie between the artery and the internal malleolus ; whilst the tendon of the flexor longus pollicis is to the outer side of the artery.

Relation to the Veins and Nerve.—The posterior tibial artery, like the other arteries below the knee, is accompanied by two venæ comites. The *posterior tibial nerve* is at first on the inner side of the artery, but in the greater part of its course the nerve is close to the outer side of the vessel.

Branches.—The posterior tibial artery furnishes numerous small branches, and one large branch—the peroneal artery.

Small Branches.—(*a*) Several *muscular* branches arise from the posterior tibial artery, and are distributed principally to the deep-seated muscles in its neighbourhood, besides one or two of considerable size to the inner part of the soleus muscle.

(*b*) The *nutrient artery* of the tibia, which is the largest of its kind in the body, arises from the posterior tibial artery near the commencement, and, after giving small branches to the muscles, enters the nutrient foramen in the bone, and ramifies on the medullary membrane. This vessel not unfrequently arises from the anterior tibial artery.

(*c*) A *communicating* branch from the peroneal artery, passing transversely, joins the posterior tibial about two inches above the ankle-joint.

The Peroneal Artery lies deeply along the back part of the leg, close to the fibula. Arising from the posterior tibial artery about an inch below the lower border of the popliteus muscle, it inclines at first obliquely towards the fibula, and then descends nearly perpendicularly along that bone and behind the outer ankle, to reach the side of the os calcis. In the upper part of its course, this artery is covered by the soleus muscle and the deep fascia, and afterwards by the flexor longus pollicis, which is placed over it as far as the outer malleolus ; below this point, the vessel is covered only by the common integument and the fascia. The peroneal artery rests at first against the upper part of the tibialis posticus muscle, and afterwards in the greater part of its course, it is surrounded by fibres of the flexor longus pollicis, lying close inside the projecting posterior ridge of the fibula. De-

scending beyond the outer malleolus, it terminates in branches on the outer surface and back of the os calcis.

Fig. 304.

Fig. 304.—Deep posterior view of the Arteries of the Leg (from Tiedemann). $\frac{1}{4}$

a, insertion of the adductor magnus muscle; *b*, origin of the inner head of the gastrocnemius; *c*, outer head and plantaris; *d*, tendon of the semimembranosus muscle; *e*, popliteus; *f*, upper part of the soleus divided below its origin from the head of the fibula; *g*, peroneus longus; *h*, flexor longus pollicis; *i*, flexor communis digitorum; 1, upper part of the popliteal artery; 2, origin of the superior articular branches; 3, origin of the inferior articular branches; the middle or azygos branch is seen between these numbers; 4, division of the popliteal artery into anterior and posterior tibial arteries; 5, 5′, posterior tibial; 6, peroneal artery; 6′, its continuation as posterior peroneal; between 5′, and 6′, the communicating branch; 7, calcaneal branches; 8, external branches of the metatarsal of the dorsalis pedis artery.

The peroneal artery gives off the following branches:—

(*a*) *Muscular* branches from the upper part of the peroneal artery pass to the soleus, the tibialis posticus, the flexor longus pollicis, and the peronei muscles.

(*b*) A *nutrient* artery enters the fibula.

(*c*) The *anterior peroneal* artery arises about two inches above the outer malleolus, and immediately piercing the interosseous membrane, descends along the front of the fibula, covered by the peroneus tertius muscle, and dividing into branches, reaches the outer ankle, and anastomoses with the external malleolar branch of the anterior tibial artery. It supplies vessels to the ankle-joint, and ramifies on the front and outer side of the tarsus, inosculating more or less freely with the tarsal arteries.

(*d*) The *terminal* branches anastomose with the external malleolar and with the tarsal arteries on the outer side of the foot; and behind the os calcis with ramifications of the posterior tibial artery.

(*e*) The *communicating* branch, lying close behind the tibia, about two inches from its lower end, is a transverse branch situated close to the bones, which connects the peroneal with the posterior tibial artery.

Peculiarities.—The *posterior tibial* artery, as well as the anterior tibial, is lengthened in those instances in which the popliteal artery divides higher up than usual. Not unfrequently the posterior tibial artery is diminished in size, and is subsequently reinforced either by a transverse branch from the peroneal in the lower part of the leg, or in rare instances, by two transverse vessels, one crossing close to the bone, and one over the deep muscles. In other instances the posterior tibial may exist only as a short muscular trunk in the upper part of the leg, while an enlarged peroneal artery takes its place from above the ankle downwards into the foot.

The *peroneal* artery has been found to arise lower down than usual, about three

inches below the popliteus muscle; and, on the contrary, it sometimes commences higher up from the posterior tibial, or even from the popliteal artery itself. In some cases of high division of the popliteal artery, the peroneal artery is transferred to the anterior tibial. It more frequently exceeds than falls short of the ordinary dimensions, being enlarged to reinforce the posterior tibial. In those rare instances in which it is lost before reaching the lower part of the leg, a branch of the posterior tibial takes its place. The anterior peroneal branch is sometimes enlarged to compensate for the small size of the anterior tibial artery in the lower part of the leg, or to supply the place of that artery on the dorsum of the foot; or it may be absent and be replaced by the anterior tibial. In a singular case, recorded by Otto, the peroneal artery was wholly wanting.

PLANTAR ARTERIES.

The external and internal plantar arteries are the branches into which the posterior tibial divides in the hollow of the calcaneum, where it is covered by the origin of the abductor pollicis.

Fig 305.

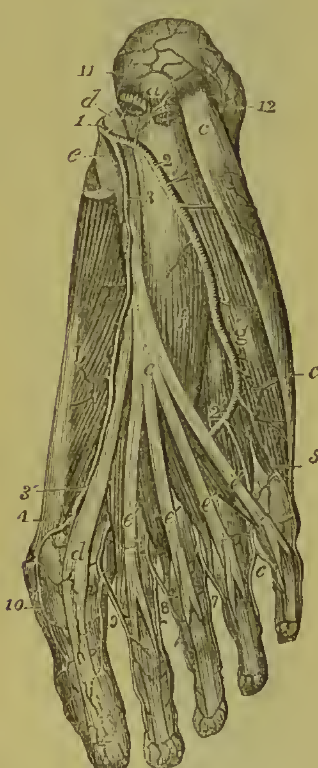


Fig. 305—Superficial view of the Arteries in the Sole of the Right Foot (from Tiedemann). ½

a, tuberosity of the calcaneum close to the origin of the flexor brevis digitorum (cut short) and the abductor pollicis, of which a part is removed to show the long flexor tendons and plantar arteries; *b*, abductor pollicis; *c*, abductor minimi digiti; *d*, tendon of the flexor pollicis longus; *e*, tendon of the flexor communis longus; *e'*, its four slips, close to the lumbricales muscles, passing on to perforate the tendons of the flexor brevis; *f*, flexor accessorius; *g*, flexor brevis minimi digiti: 1, posterior tibial dividing into the plantar arteries; 2, 2', external plantar; 3, internal plantar; 3', the same passing forward to communicate with 4, the internal plantar digital branch for the great toe; 5, first digital or external plantar branch to the fifth toe; 6, placed in the angle of division of the second plantar digital artery, between the fourth and fifth toes; 7, the third plantar digital artery dividing similarly between the third and fourth toes; 8, the fourth plantar digital artery dividing similarly between the second and third toes; 9, the plantar digital artery dividing similarly between the first and second toes; 10, internal plantar artery of the great toe; 11, calcaneal branches of the plantar arteries, anastomosing with 12, the calcaneal branches of the posterior peroneal artery.

The *internal plantar* artery, much smaller than the external, is directed forwards, along the inner side of the foot. Placed at first under cover of the abductor pollicis, it passes forwards in the groove between that muscle and the short flexor of the toes, near the line separating the middle from the inner portion of the plantar fascia, and on reaching the extremity of the first metatarsal bone, considerably diminished in size, it terminates by running along the inner border of the great toe, anastomosing with the digital branches.

Branches.—The internal plantar artery gives off numerous small twigs, which may be distinguished in sets as follows:—(*a*) muscular branches to the abductor

pollicis and flexor brevis digitorum; (*b*) offsets which incline towards the inner border of the foot, and communicate with branches of the dorsal arteries; and (*c*) cutaneous offsets which appear in the furrow between the middle and inner portions of the plantar fascia.

The *external plantar* artery, of considerable size, at first inclines outwards and then forwards, to reach the base of the fifth metatarsal bone: it then turns obliquely inwards across the foot, to gain the interval between the bases of the first and second metatarsal bones, where it joins, by a communicating branch, with the dorsal artery of the foot; and thus is completed the *plantar arch*, the convexity of which is turned forward. At first the artery is placed, together with the external plantar nerve, between the calcaneum and the abductor pollicis; further on it lies between the flexor brevis digitorum and flexor accessorius. As it turns forwards it lies in the interval between the short flexor of the toes and the abductor of the little toe, being placed along the line separating the middle from the external portion of the plantar fascia, and covered by that membrane. The remainder of the artery, which turns inwards and forms the plantar arch, is placed deeply against the interosseous muscles, and is covered by the flexors of the toes and the lumbricales muscles.

BRANCHES.—

A. *In its course to the fifth metacarpal bone* the external plantar artery gives off (*a*) branches to the skin of the heel; (*b*) numerous muscular branches; (*c*) small

Fig. 306.

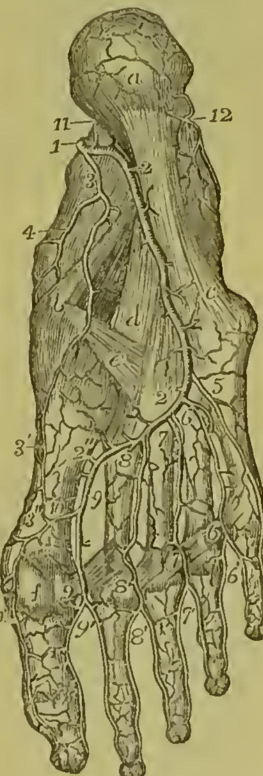


Fig. 306.—DEEP VIEW OF THE ARTERIES IN THE SOLE OF THE RIGHT FOOT (from Tiedemann). $\frac{1}{3}$

All the muscles have been removed. *a*, the calcaneal tuberosity; *b*, the scaphoid bone and end of the calcaneo-scaphoid ligament; *c*, to *a*, calcaneo-cuboid ligament; *d*, its deep part; *e*, scaphoido-cuneiform ligament; *f*, one of the sesamoid bones of the great toe; 1, posterior tibial artery dividing into the plantar arteries; 2, 2′, external plantar artery; 2′, 2″, deep plantar arch terminating by communication with the dorsal artery of the foot; 3, 3′, internal plantar artery; 3″, its communication with the internal digital of the great toe; 4, branches of the internal plantar to the inside of the foot; 5, 5′, first digital or external plantar branch of the fifth toe; 6, second plantar digital artery; 6′, interval of the division of the same between the fourth and fifth toes; 7, third plantar digital; 7′, its distribution to the third and fourth toes; 8, fourth plantar digital; 8′, its distribution to the second and third toes; 9, fifth plantar digital; 9′, its distribution to the first and second toes; 10, internal plantar digital branch of the great toe; at the upper numbers, 6, 7, and 8, the posterior perforating branches of the interosseous arteries are partially indicated; at 2″, the large communication between the plantar arch and the dorsalis pedis artery; above 6′, 7′, and 8′, are situated the anterior perforating arteries, not represented in the figure; 11, and 12, calcaneal branches of the plantar and posterior peroneal arteries.

offsets which run outwards over the border of the foot, and anastomose with the dorsal arteries; and (*d*) others which appear in the furrow between the middle and outer divisions of the plantar fascia.

B. *From the plantar arch* are given off the following more important branches :—

(*a*) The *posterior perforating* branches, three in number, pass upwards through the back part of the three outer interosseous spaces, between the heads of the dorsal interosseous muscles, and on reaching the dorsum of the foot inosculate with the interosseous branches of the metatarsal artery.

(*b*) The *digital* branches are four in number. The *first* digital branch inclines outwards from the outermost part of the plantar arch, opposite the end of the fourth metatarsal space, crosses under cover of the abductor minimi digiti, and runs along the outer border of the phalanges of the little toe. The *second* digital branch passes forwards along the fourth metatarsal space, and near the cleft between the fourth and fifth toes divides into two vessels, which course along the contiguous borders of those toes, and end on the last phalanges. The *third* digital branch is similarly disposed of on the fourth and third toes. The *fourth* ends in like manner on the third and second toes.

The digital artery which supplies the opposed sides of the first and second toes, and that which runs on the inner side of the first toe, arise deeply between the first and second metatarsal bones, usually from that part of the arch which is formed by the end of the dorsal artery of the foot.

Thus, as in the fingers, *collateral* arteries pass along the sides of the flexor surface of each of the toes. Near the base of the last phalanx these inosculate so as to form an arch, from the convexity of which minute vessels pass forwards to the extremity of the toe, and to the matrix of the nail.

An *anterior perforating* branch is sent upwards by each of the digital arteries of the three outer interspaces near its bifurcation, to communicate with the corresponding digital branch of the metatarsal artery of the dorsum of the foot.

Peculiarities.—The posterior perforating branches, which are usually very small vessels, are sometimes enlarged, and furnish the interosseous arteries on the upper surface of the foot; the metatarsal branch of the dorsal artery, from which the interosseous arteries are usually derived, being in that case very small.

ANTERIOR TIBIAL ARTERY.

The anterior tibial artery, placed along the fore part of the leg, is at first deeply seated, but gradually approaches nearer to the surface as it descends. It extends from the division of the popliteal artery to the bend of the ankle; whence it is afterwards prolonged to the interval between the first and second metatarsal bones, under the name of *dorsal artery* of the foot.

The anterior tibial artery is at first directed forwards to reach the anterior surface of the interosseous ligament, passing through the divided upper end of the tibialis posticus, and through the interval left unoccupied by the interosseous ligament. It then extends obliquely downwards to the middle of the ankle-joint, in a direction which may be nearly indicated by a line drawn from the inner side of the head of the fibula to midway between the two malleoli. Lying with the tibialis anticus on its inner side, and having the extensor communis digitorum and, lower down, the extensor proprius pollicis on its outer side, the vessel is deeply placed at the upper part of the leg, where those muscles are fleshy; but it is comparatively superficial below, between their tendons, and comes forward upon the tibia. At the bend of the ankle it is covered by the annular ligament, and is crossed from without inwards by the tendon of the extensor proprius pollicis. In its

oblique course downwards the anterior tibial artery lies at first close to the

Fig. 307.—Anterior view of the Arteries of the Leg and Dorsum of the Foot (from Tiedemann) $\frac{1}{4}$

The tibialis anticus muscle is drawn towards the inner side so as to bring the anterior tibial artery into view, the extensor proprius pollicis, the long common extensor of the toes, and the peroneus tertius muscles in their lower part, and the whole of the extensor communis brevis, have been removed. 1, external superior articular branch of the popliteal artery, ramifying on the parts surrounding the knee; and anastomosing with the other articular branches and with 2, the recurrent branch of the anterior tibial artery; 3, 3, anterior tibial, giving off muscular branches on each side; 4, dorsal artery of the foot; 5, external anterior malleolar artery coming off from the anterior tibial, and anastomosing with the anterior peroneal artery which is seen descending upon the lower part of the fibula: the internal malleolar is represented proceeding from the other side of the anterior tibial artery; 6, the tarsal branch of the dorsal artery, represented in this instance as larger than usual and furnishing some of the branches of the next artery; 7, the metatarsal branch, giving off the dorsal interosseous arteries; (in the first interosseous space the dorsal artery of the foot is seen to give off the anastomosing branch which unites with the deep plantar arch;) between 8, and 8, the collateral branches of the dorsal digital arteries.

Fig. 307.

interosseous ligament, and is then at a considerable distance from the spine of the tibia; but in descending it gradually approaches that ridge, and towards the lower part of the leg is supported on the anterior surface of the bone.

Relation to Veins and Nerves.—The anterior tibial artery is accompanied by two veins (venæ comites). The *anterior tibial nerve*, coming from the outer side of the head of the fibula, approaches the artery at some distance below the place where the vessel appears in front of the interosseous ligament. Lower down, the nerve for the most part lies in front of the artery, but often changes its position from the one side of the vessel to the other.

Branches.—Besides numerous small muscular branches, the anterior tibial artery furnishes the following:—

(*a*) The *recurrent artery*, given off as soon as the anterior tibial reaches the front of the leg, ascends through the fibres of the tibialis anticus, and, ramifying on the outside and front of the knee-joint, anastomoses with the inferior articular and other branches of the popliteal artery.

(*b*) The *malleolar arteries*, two in number, external and internal, are given off near the ankle-joint, but are very variable in size and mode of origin. The *internal* branch passes beneath the tendon of the

tibialis anticus to the inner ankle, and communicates with branches of the posterior tibial artery. The *external* branch passes outwards under the tendon of the common extensor of the toes, and anastomoses with the anterior division of the peroneal artery, and also with some ascending or recurrent branches from the tarsal branch of the dorsal artery of the foot.—These malleolar arteries supply articular branches to the neighbouring joints.

DORSAL ARTERY OF THE FOOT.

The dorsal artery of the foot (dorsalis pedis), the continuation of the anterior tibial artery, extends from the termination of that vessel at the bend of the ankle, to the posterior end of the first metatarsal space. At this spot it divides into two branches, of which one proceeds forwards in the first interosseous space, whilst the other dips into the sole of the foot, and terminates by inosculating with the plantar arch. The dorsal artery of the foot lies in the interval between the tendon of the proper extensor of the great toe, and that of the long extensor of the other toes ; and is covered by a deep layer of fascia, which binds it to the parts beneath. Near its end it is crossed by the innermost tendon of the short extensor of the toes.

Two veins accompany this artery ; the anterior tibial nerve lies on its outer side.

BRANCHES.—The principal branches of the dorsal artery of the foot are directed outwards and forwards upon the tarsus and metatarsus, and are named accordingly. Some small offsets also run obliquely inwards, and ramify upon the inner side of the foot.

(*a*) The *tarsal* branch arises from the artery usually where it crosses the scaphoid bone, but its point of origin varies in different instances. It inclines forwards and outwards upon the tarsal bones covered by the short extensor muscle of the toes, then curving backwards towards the cuboid bone, divides into branches which take different directions over the tarsus.

The *branches* supply the extensor brevis digitorum muscle and the tarsal joints, and anastomose with the external plantar, the metatarsal, the external malleolar, and the peroneal arteries.

(*b*) The *metatarsal* artery arises farther forwards than the preceding vessel, and is directed outwards like it, beneath the short extensor muscle. Sometimes there are two metatarsal arteries, the second being of smaller size ; and not unfrequently, when there is but a single vessel of this name, it arises in common with the tarsal artery. Its direction is necessarily influenced by these circumstances ; being oblique when it arises far back, and almost transverse when its origin is situated farther forwards than usual. It anastomoses with the tarsal and external plantar arteries, and gives off interosseous branches.

The three *interosseous* branches from the metatarsal artery are small straight vessels which pass forwards along the three outer interosseous spaces, resting upon the dorsal interosseous muscles. Somewhat behind the clefts between the toes each divides into two branches, which run forward along the contiguous borders of the corresponding toes, forming their dorsal collateral branches. Moreover, from the outermost of these interosseous arteries a small branch is given off, which gains the outer border of the little toe, and forms its external collateral branch. These arteries communicate with the plantar arch opposite the fore part of the interosseous spaces, by means of the *anterior perforating* branches, and at the back part of the interosseous spaces, by the *posterior perforating* branches.

(c) The *first interosseous branch*, or *dorsal artery of the great toe*, is con-

Fig. 308.

Fig. 308.—Anterior view of the Arteries of the Leg and Dorsum of the Foot (from Tiedemann). $\frac{1}{4}$

The tibialis anticus muscle is drawn towards the inner side so as to bring the anterior tibial artery into view, the extensor proprius pollicis, the long common extensor of the toes, and the peroneus tertius muscles in their lower part, and the whole of the extensor communis brevis, have been removed. 1, external superior articular branch of the popliteal artery, ramifying on the parts surrounding the knee; and anastomosing with the other articular branches and with 2, the recurrent branch of the anterior tibial artery; 3, 3, anterior tibial, giving off muscular branches on each side; 4, dorsal artery of the foot; 5, external anterior malleolar artery coming off from the anterior tibial and anastomosing with the anterior peroneal artery which is seen descending upon the lower part of the fibula: the internal malleolar is represented proceeding from the other side of the anterior tibial artery; 6, the tarsal branch of the dorsal artery, represented in this instance as larger than usual and furnishing some of the branches of the next artery; 7, the metatarsal branch, giving off the dorsal interosseous arteries; (in the first interosseous space the dorsal artery of the foot is seen to give off the anastomosing branch which unites with the deep plantar arch;) between 8 and 8, the collateral branches of the dorsal digital arteries.

tinued forwards from the dorsal artery of the foot at the point where it dips down to the sole. This branch runs along the outer surface of the first metatarsal bone, and furnishes the small *dorsal digital* vessels of the great toe and adjacent side of the second toe.

(d) The *plantar digital branch of the innermost space*, given off from the dorsal artery between the heads of the first interosseous muscle, near the inosculation with the plantar arch, passing forwards divides into two smaller branches which proceed along the contiguous sides of the first and second toe.

(e) The *plantar digital branch for the inner side of the great toe* crosses beneath the first metatarsal bone, and runs along the inner side of the great toe on its plantar surface.

Peculiarities *of the anterior tibial artery. Origin.*—In cases of early division of the popliteal artery, the place of origin of the anterior tibial is necessarily higher up than usual, being sometimes found as high as the bend of the knee-joint. In some of these cases (the posterior tibial artery being small or wanting), the anterior tibial is conjoined with the peroneal artery. When the anterior tibial arises higher than usual, the additional upper part of the vessel has been seen resting on the posterior surface of the popliteus muscle, and it has been likewise found between that muscle and the bone.

Course.—The anterior tibial artery, having its usual place of origin, has been found to deviate outwards towards the margin of the fibula in its course along the front of the leg, and then to return to its ordinary position beneath the annular ligament in front of the ankle-joint. This artery has been also noticed by Pelletan and by Velpeau to approach the surface at the middle of the leg, and to continue downwards from that point, covered only by the fascia and integument. Velpeau states that he found the artery to reach the fore part of the leg by passing round the outer side of the fibula. (Pelletan, "Clinique Chirurgicale," &c., p. 101 : Paris, 1810. Velpeau, "Nouveaux Elémens de Médecine Opératoire," &c., t. i, pp. 137 and 537 : Paris, 1837.)

Size.—This vessel more frequently undergoes a diminution than an increase of size.

It may be defective in various degrees. Thus, the dorsal branch of the foot may fail to give off digital branches to the great and second toes, which may be then derived from the internal plantar division of the posterior tibial. In a farther degree of diminution the anterior tibial ends in front of the ankle or at the lower part of the leg; its place being then taken by the anterior division of the peroneal artery, which supplies the dorsal artery of the foot; the two vessels (anterior tibial and anterior peroneal) being either connected together or separate.

Two cases are mentioned by Allan Burns, in which the anterior tibial artery was altogether wanting, its place in the leg being supplied by perforating branches from the posterior tibial artery, and on the dorsum of the foot by the anterior division of the peroneal artery.

The dorsal artery of the foot is occasionally larger than usual; in that case compensating for a defective condition of the plantar branch from the posterior tibial artery.

This artery has been repeatedly found to be curved outwards between its commencement at the lower border of the annular ligament and its termination in the first interosseous space.

VEINS.

The systemic veins commence by small branches which receive the blood from the capillaries throughout the body, and unite to form fewer and larger vessels, which end at last by pouring their contents into the right auricle of the heart through two large venous trunks, the superior and inferior venæ cavæ. The blood which nourishes the substance of the heart itself, is returned by the coronary or cardiac veins to the same auricle.

The veins, however, which bring back the blood from the stomach, intestines, spleen and pancreas, have an exceptional destination ; not conveying the blood directly to the heart, but joining to form a single trunk—the portal vein, which ramifies after the manner of an artery in the substance of the liver, and carries the blood within it to the capillaries of that organ. From these the blood passes into the ultimate twigs of the hepatic veins, and is conveyed by these veins into the inferior vena cava. The veins thus passing to the liver constitute the *portal system.*

The anastomoses of veins are much larger and more numerous than those of arteries. The veins of many parts of the body consist of a subcutaneous and a deep set, which have very frequent communications with each other. In some parts of the body, chiefly the limbs and surface, the veins are provided with valves, whilst in others no valves exist.

The systemic veins are naturally divisible into two groups : firstly, those from which the blood is carried to the heart by the superior vena cava, viz., the veins of the head and neck and upper limbs, together with those of the spine and a part of the walls of the thorax and abdomen, with which may be associated also the veins of the heart ; and secondly, those from which

the blood is carried to the heart by the inferior vena cava, viz., the veins of the lower limbs, the lower part of the trunk, and the abdominal viscera. (For a general representation of the venous system, see fig. 224 at p. 298.)

UPPER VENA CAVA.

The *upper vena cava* conveys to the heart the blood which is returned from the head, the neck, the upper limbs, and the thorax. It is formed by the union of the right and left brachio-cephalic veins. It extends from a little below the cartilage of the first rib on the right side of the sternum to the base of the heart, where it opens into the right auricle. Its course is slightly curved, the convexity of the curve being turned to the right side. It has no valves. At about an inch and a half above its termination, it is invested by the fibrous layer of the pericardium, the serous membrane being reflected over it. The upper cava lies immediately in front of the right pulmonary vessels, and between the right lung and the aorta, which partly overlap it. It receives several small veins from the pericardium and the mediastinum ; and lastly, it is joined by the right azygos vein, immediately above the place where it becomes invested by the pericardium.

Peculiarity.—In several instances, the two innominate veins, which usually join to form the vena cava superior, have been seen to open separately into the right auricle. This peculiarity is explained by reference to the development of the parts, and is more fully referred to at p. 485, in connection with the description of the great cardiac vein.

INNOMINATE OR BRACHIO-CEPHALIC VEINS.

The blood returned from the upper limbs through the subclavian veins, and from the head and neck by the jugular veins, is poured into two trunks, named the brachio-cephalic or innominate veins. These vessels, resulting from the union of the subclavian with the internal jugular vein at each side, commence opposite the inner ends of the clavicles, and terminate a little below the cartilage of the first rib on the right side, where, by uniting, they form the upper vena cava. The right vein is very short, and nearly vertical in its direction ; it is in apposition, on the right side, with the pleura and the upper part of the right lung. The vein of the left side, about three times longer than the right vein, pursues a course from left to right, at the same time inclining somewhat downwards : it crosses behind the upper part of the first bone of the sternum, separated from it by the sterno-hyoid and sterno-thyroid muscles, and by the thymus gland or its remains ; it lies in front of the three primary branches given off from the arch of the aorta, and rests upon the highest part of the arch. The innominate veins have no valves.

Lateral tributaries.—(*a*) The *inferior thyroid* veins emerge from a venous plexus situated on the thyroid body—those of opposite sides communicating by small branches across the trachea. The vein of the left side descends in front of the trachea, behind the sterno-thyroid muscles, and ends in the left brachio-cephalic or innominate vein : that of the right side inclines outwards in some degree, and opens into the corresponding brachio-cephalic vein, or into the angle of union between it and the vessel of the opposite side.

(*b*) The *internal mammary* veins follow exactly the course of the arteries of the same name—two veins accompanying each of the arteries. The two companion veins of the artery arise by small branches, derived from the

fore part of the walls of the abdomen, where they anastomose with the

Fig. 309.

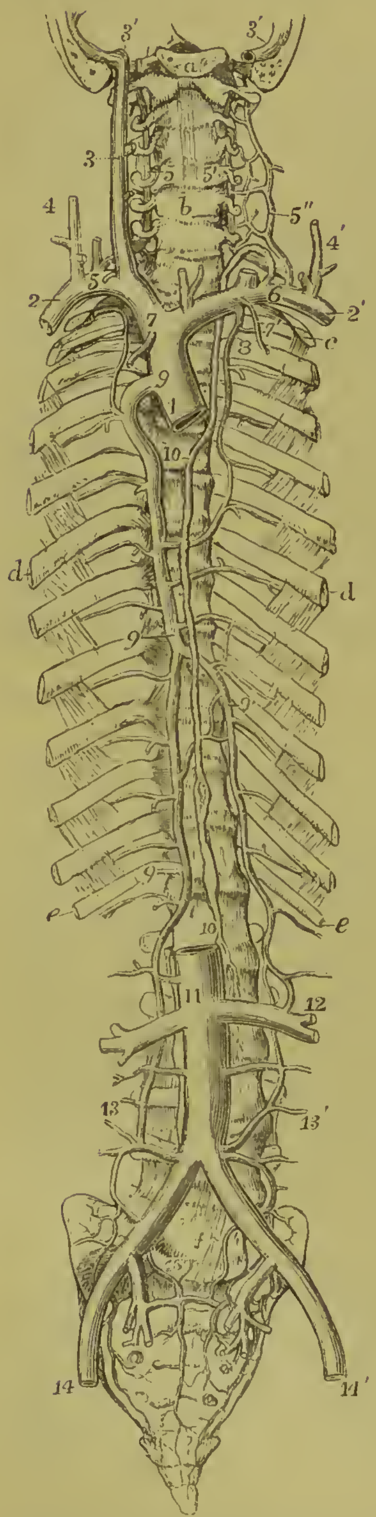


Fig. 309.—Sketch of the Principal Venous Trunks, together with the Thoracic Duct. $\frac{1}{5}$

a, the basilar process of the occipital bone, through which and the temporal bones a transverse incision has been made so as to lay open the jugular foramen on both sides ; *b*, the body of the fifth cervical vertebra ; *c*, the first rib ; *d*, the sixth ; *e*, the twelfth ; *f*, the body of the fifth lumbar vertebra ; 1, trunk of the vena cava superior divided at the place of its entrance into the right auricle ; 2, right, 2′, left subclavian veins ; 3, right internal jugular vein ; the left is cut short immediately above the place where it joins the subclavian vein ; 3′, 3′, lower part of the lateral sinuses of the dura mater ; that of the left side is divided inferiorly ; that of the right side shows at its junction with the jugular vein the bulb which lies in the jugular depression of the temporal bone ; 4, right, and 4′, left external jugular veins ; 5, right, and 5′, left vertebral veins anastomosing with 5″, external vertebral veins, before joining the subclavian veins ; 6, placed on left subclavian vein below the opening of the last, and of the thoracic duct ; below *b*, the inferior thyroid veins ; 7, 7′, the internal mammary veins ; 8, the left superior intercostal vein joining the left brachio-cephalic vein, and anastomosing below with intercostal veins which join the trunk of the azygos ; the right superior intercostal vein is seen joining the azygos vein ; 9, main or right azygos vein ; the uppermost figure points to the curved portion, which passes over the right bronchus before joining the vena cava superior ; 9′, the left azygos, represented here as crossing the vertebral column on the eighth vertebra ; 10, the thoracic duct ; the upper figure is on the fourth dorsal vertebra, the lower on the first lumbar close to the receptaculum chyli ; 11, trunk of the inferior vena cava divided below the liver ; the figure is immediately over the place of origin of the renal veins ; below it is seen dividing on the fourth lumbar vertebra into the two common iliac veins ; 12, the union of the left azygos vein with the left renal vein ; 13, on the right side, the commencement of the right azygos vein in the lumbar region, joined by several lumbar veins ; 13′, the commencement of the azygos vein of the left side, joining similar veins on that side ; 14, 14′, the external iliac veins ; 15, placed on the promontory of the sacrum, points on either side to the prolongation of the lower branches of the right and left lumbar veins into the pelvis, and their union with sacral and other branches of the internal iliac veins.

epigastric veins ; from thence proceeding upwards between the cartilages of the ribs and the pleura, they receive the *anterior intercostal* veins which correspond with the branches of the internal mammary artery, together with some small *diaphragmatic*, *thymic* and *mediastinal* veins, and

these finally uniting into a single trunk, each vein terminates in the brachiocephalic of its own side.

(c) The *superior intercostal* veins. — The right superior intercostal vein receives the blood from the first or the first two or three spaces, communicating with the vessel in the space next below, and opens into the innominate trunk oft he same side, or into the vena cava. Frequently the veins at the right side, corresponding with the superior intercostal artery, pass downwards separately, to open into the azygos vein, as that vessel arches forwards to join the upper vena cava: the separate vein thus formed is inferior in size to that on the left side. The *left* superior intercostal vein varies in length in different persons, being small when the azygos minor is large, and *vice versâ.* Usually it receives the veins from the three or four upper spaces, and is then directed forwards over the left side of the spinal column and the aorta to open into the left innominate vein. It receives in its course the left bronchial vein. The left vein is sometimes directed downwards to join an azygos vein on its own side.

VEINS OF THE FACE, NECK, AND HEAD.

The blood returning from the head and neck flows on each side into two principal veins, the external and internal jugular. The veins of the head and neck have generally no valves. The external jugular vein is provided with a valve at its entrance into the subclavian vein, and in most cases with another about the middle of its course: and the internal jugular is also furnished with valves near its junction with the subclavian. These valves, however, are not efficient in stopping the regurgitation of the blood, or the passage of injections from below upwards.

The veins on the exterior of the cranium and face converge and unite, so as to form two trunks, the facial and the temporal veins.

THE FACIAL VEIN.

The *facial* vein lies obliquely along the side of the face, extending from the inner margin of the orbit downwards and outwards to the anterior border of the masseter muscle. Resting on the same plane as the facial artery, but farther back, and less tortuous, it has very nearly the same relations to contiguous parts. It commences at the side of the root of the nose by a vein formed by the junction of branches from the forehead, eyebrow and nose, and increases by receiving others during its course. Below the jaw it inclines outwards and backwards, covered by the cervical fascia and the platysma muscle; and soon unites with a large branch of communication derived from the temporal vein, to form the *temporo-maxillary or common facial* vein, a short vessel of considerable size, which joins obliquely the trunk of the internal jugular.

Tributaries.—(*a*) The *frontal* vein commences on the roof of the skull by branches, which descend obliquely inwards upon the forehead, maintaining communications in their course with the anterior branches of the temporal vein. It descends vertically, parallel with the corresponding vessel of the opposite side, with which it is connected by transverse branches, and ends in the angular vein. In some instances the veins of the two sides unite and form a short trunk, which again divides into two branches at the root of the nose. As it descends from the forehead, the frontal vein receives a branch from the eyebrow, and some, of smaller size, from the nose and upper eyelid.

(*b*) The *supra-orbital* vein (v. supercilii) runs inwards in the direction of the eyebrow, covered by the occipito-frontalis muscle. Its branches are connected externally with those of the external palpebral and superficial temporal veins; in its course it receives branches from the contiguous muscles and integument, and at the inner angle of the orbit inclines downwards to terminate in the frontal vein.

Fig. 310.

Fig. 310.—View of the Superficial Veins of the Head and Neck.

1, sterno-mastoid muscle; *a*, facial vein; *b*, temporal vein; *c*, transverse facial; *d*, posterior auricular; *e*, internal maxillary vein; *f*, external jugular vein; *g*, posterior external jugular; *h*, anterior jugular; *i*, posterior scapular and suprascapular veins; *k*, internal jugular vein; *l*, occipital veins; *m*, subclavian vein: above the inner side of the orbit are shown the frontal and supraorbital veins, and their descending branches to anastomose with the angular or terminal branch of the facial vein.

(*c*) The *angular* vein, formed by the junction of the supra-orbital and frontal veins, is perceptible beneath the skin as it runs obliquely downwards and outwards near the inner margin of the orbit, resting against the side of the nose at its root. This vessel receives on the inner side the *nasal veins,* which pass upwards obliquely to join it from the side and ridge of the nose; whilst some small *superior palpebral* veins open into it from the opposite direction. On a level with the lower margin of the orbit it becomes continuous with the facial vein.

(*d*) The *inferior palpebral* veins, two or three in number, are derived from the lower eyelid, from the outer side of the orbit, and from the cheek. They pass in a direction obliquely inwards above the zygomatic muscle, and then turn beneath it previously to their termination.

(*e*) *Communicating* branches from the pterygoid plexus (deep facial, anterior internal maxillary); and also some branches proceeding from the orbit, furnished by the *infra-orbital* of the internal maxillary vein, join the facial on a level with the angle of the mouth.

(*f*) *Labial, buccal, masseteric* and *mental* branches join the facial below the angle of the mouth.

(*g*) The *ranine* vein, a small vessel which lies along the under surface of the tongue, close to the frænum linguæ, is in apposition with the artery of the same name: its course is backwards and outwards, between the mylo-hyoid and hyo-glossus muscles, to open into the facial vein, or sometimes into the lingual.

(*h*) The *submental* vein, larger than the preceding, commences below the chin; it receives branches from the submaxillary gland, and from the mylo-hyoid muscle, and, keeping close under cover of the margin of the jaw-bone, joins the facial vein; but in some instances it enters the lingual or superior thyroid vein.

(*i*) *Submaxillary* branches from the gland join the facial vein either separately or united into one trunk.

(*j*) The *palatine* vein returns the blood from the plexus round the tonsil and

from the soft palate; it passes downwards, deeply seated by the side of the pharynx, to join one of the preceding veins, or terminate in the facial separately.

THE TEMPORAL VEIN.

The *temporal* vein, a vessel of considerable size, descends in front of the external auditory tube, reaching from the zygoma, upon which it rests, to the angle of the jaw. It results from the union of branches which are spread out upon the side of the head, some superficially, and others deeply seated. The *superficial* branches commence upon the arch of the skull, where they communicate with the ramifications of the frontal and occipital veins, as well as with those of the corresponding vein of the opposite side. Descending on the surface of the temporal fascia, they converge; those from the fore part inclining a little backwards, while the posterior branches run forwards over the ear; and the two sets joining together above the zygoma form the trunk of the temporal vein. The deeper branches, arising in the substance of the temporal muscle, unite to form a vein of some size, called the *middle temporal*, to distinguish it from branches still more deeply placed, and which open into the internal maxillary vein. The middle temporal vein falls into the common temporal trunk at its commencement above the zygoma. The temporal vein gradually sinks into the substance of the parotid gland as it descends behind the ramus of the jaw. Beneath the angle of that bone, it divides into two vessels, one of which turns backwards, and forms the commencement of the external jugular vein, while the other communicates with the facial vein near its termination.

LATERAL TRIBUTARIES.—These are numerous:—(*a*) *parotid* branches from the parotid gland; (*b*) *articular*, from the articulation of the jaw; (*c*) *anterior auricular* veins from the external ear; (*d*) the *transverse facial*, a branch of considerable size, corresponding with the transverse facial artery; (*e*) the *posterior auricular* directed forwards from behind, and joined by the stylo-mastoid vein; and (*f*) the *internal maxillary* vein, a large vessel, which requires more particular description.

THE INTERNAL MAXILLARY VEIN.

The *internal maxillary* vein corresponds somewhat in direction and position with the artery of the same name, and receives branches from the neighbouring parts, most of which are the venæ comites of the corresponding divisions of the internal maxillary artery. Thus three or four *deep temporal* branches descend from the temporal muscle; others come from the pterygoid, masseter, and buccinator muscles. The middle *meningeal* veins and some *palatine* veins also end in the internal maxillary; and lastly, branches from the surface of the upper jaw—*superior dental*, and another, of large size, from the lower jaw, emerging from the dental foramen—*inferior dental*. These different branches form a plexus of veins, named *pterygoid plexus*, which is placed in the lower part of the temporal fossa, between the temporal and the external pterygoid muscle, and in part between the pterygoid muscles. It communicates in front with the facial vein, and above, with the cavernous sinus by branches through the base of the skull. From this plexus proceed one or two short trunks, which join nearly at right angles with the temporal vein.

The FACIAL COMMUNICATING vein, extending between the temporal vein at the angle of the jaw and the facial vein, a little in front of it, is a short trunk, usually the larger of the two into which the temporal vein divides, and placed nearly transversely, so as to allow the flow of blood either from

the temporal into the internal jugular vein, or from the facial into the external jugular.

Fig. 311.

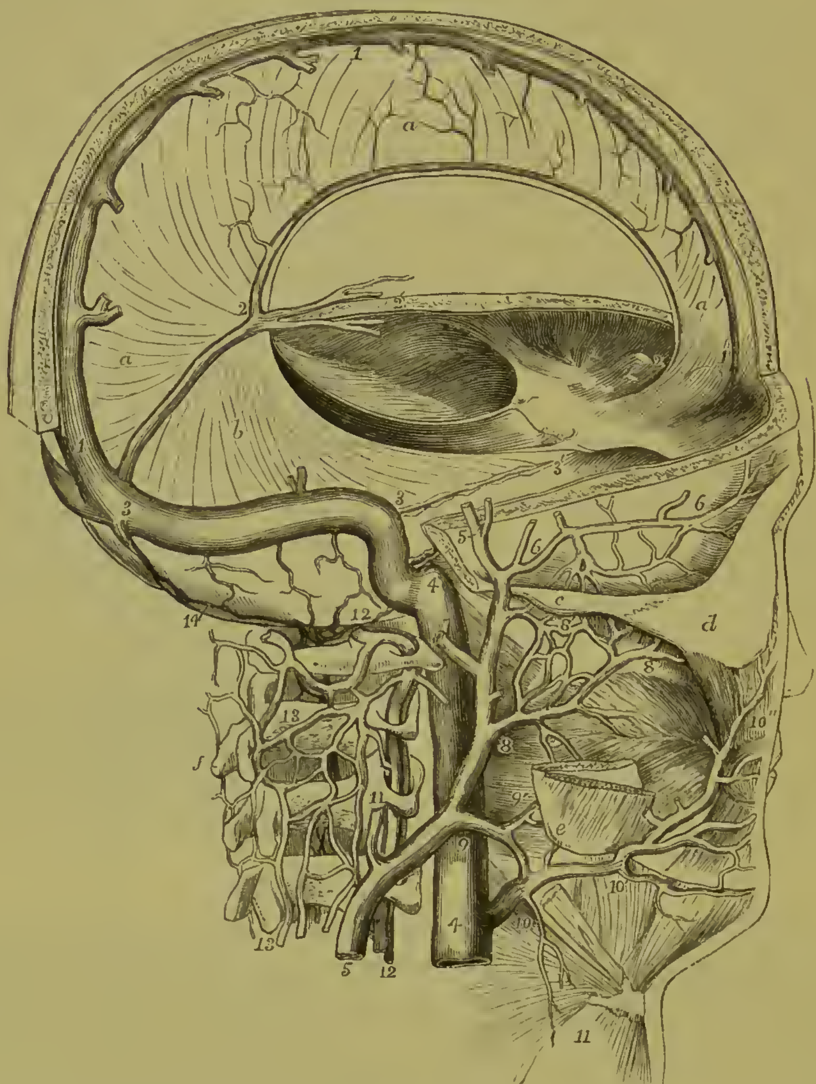


Fig. 311.—Diagrammatic view of the Sinuses of the Dura Mater and some of the Deep Veins of the Neck and Head (modified from Cloquet and other sources). ½

The greater part of the calvarium has been removed; but an arched strip has been kept in the fore and upper part of the region of the superior longitudinal sinus. The occiput has been entirely removed so as to expose the lateral sinus and its termination in the jugular vein. *a*, the falx cerebri; *b*, the tentorium cerebelli of the right side; *c*, zygomatic arch; *d*, malar bone; *e*, angle of the jaw; *f*, spinous process of the axis vertebra; 1, superior longitudinal sinus; 2, inferior longitudinal sinus; 2, 3, straight sinus; 2′, internal veins of the brain (veins of Galen); 3, lateral sinus, descending to 4, the commencement of the internal jugular; 3′, superior petrosal sinus; 4, 4, the internal jugular vein; 5, 5, superficial temporal vein, leading into the external jugular vein; 6, middle temporal; 7, posterior auricular; 8, internal maxillary; 8′, pterygoid plexus and communications with the deep temporal veins; 9, communicating branch between the facial, temporal and external jugular; 9′, pharyngeal branches; 10, facial vein; 10′, submental branch; 10″, continuation of the facial into the angular; 11, an occasional branch from the neck; 12, vertebral vein and artery; 13, external spinal veins forming a plexus over the vertebral arches; 14, occipital sinus communicating above the atlas with the spinal plexus.

THE EXTERNAL JUGULAR VEIN.

The *external jugular* vein commences on a level with the angle of the lower maxilla, at the end of the temporal vein, and descends perpendicularly between the platysma and fascia, crossing the sterno-mastoid muscle. In consequence of the oblique direction of that muscle, the vein gets to its outer border, and continues behind it down to the lower part of the neck, where it pierces the fascia to terminate either as a single trunk, or by two or three branches in the subclavian vein. It is provided with a valve at its lower end, and in most cases with another about the middle of its course.

Tributaries.—The external jugular vein receives some large branches from behind, and superficial branches from the fore part of the neck. The largest branches are the following :—

(*a*) The *posterior* branch, lying at first between the splenius and trapezius muscles, passes down at the outside of the jugular vein, and below the middle of the neck opens into that vessel.

(*b*) The *supra-scapular* and *posterior scapular* veins, corresponding to the arteries of the same name, pass transversely inwards to join the external jugular vein close to its termination.

The *anterior jugular* vein arises from the convergence of some superficial branches in the submaxillary region. This vessel lies along the fore part of the neck, sometimes near the sterno-mastoid muscle, and either terminates by inclining outwards to join the external jugular vein, or, after giving to it a branch of communication, sinks beneath the sterno mastoid muscle, and ends in the subclavian vein. The lower ends of the two anterior jugular veins are frequently united by a transverse branch placed behind the sterno-mastoid muscles and top of the sternum.

The external jugular vein is very variable in size. It is frequently very small, and may be absent altogether. The anterior jugular vein is likewise very variable.

INTERNAL JUGULAR VEIN.

The *internal jugular* veins, receiving the blood from the brain and cranial cavity, are continuous at their upper extremities with the lateral sinuses within the cranium, and terminate inferiorly in the innominate or brachio-cephalic veins. The commencement of each internal jugular vein at the wide part (*jugular fossa*) of the foramen jugulare, is somewhat enlarged, and has been named the *sinus* or *gulf* of the internal jugular vein. Beneath the skull, the vein is supported by the rectus lateralis muscle, and lies close to the outer side of the internal carotid artery, as far as the cornu of the os hyoides. It is joined at this point by the common facial vein, and becomes considerably enlarged ; it then descends parallel with the common carotid artery, lying at its outer side and enclosed in the same sheath, together with the vagus nerve. At the root of the neck it joins nearly at a right angle with the subclavian vein, and so forms the innominate or brachio-cephalic vein. Close to the lower termination of the jugular, or from half an inch to an inch above it, is placed a double valve as in other veins. ("Struthers, Anat. and Phys. Observ.," p. 173.)

Tributaries.—Previously to its junction with the facial vein, the internal jugular receives the lingual, pharyngeal, and occipital veins ; one or more of which, however, very frequently end in the common facial trunk.

(*a*) The *lingual* vein begins at the side and upper surface of the tongue, and passes backwards, receiving branches from the sublingual gland ; occasionally the ranine vein joins it, and sometimes also the pharyngeal.

(*b*) The *pharyngeal* vein commences at the back and sides of the pharynx, and sometimes ends in the superior thyroid vein, and at other times in the lingual, or separately in the internal jugular vein.

(*c*) The *occipital* vein, corresponding in course and distribution with the occipital artery, communicates with a plexus of veins upon the occiput, and terminates occasionally in the external jugular vein, but more frequently in the internal.

(*d*) The *common facial* vein has been already described.

(*e*) The *laryngeal* vein receives branches from the larynx through the thyro-hyoid membrane, and opens into the internal jugular, the common facial, or sometimes into the superior thyroid vein.

(*f*) The *superior thyroid* vein commences by branches in the thyroid body, in company with those of the superior thyroid artery, and runs transversely outwards.

(*g*) The *middle thyroid* vein, likewise derived from the thyroid body, is placed lower than the superior thyroid.

VENOUS CIRCULATION WITHIN THE CRANIUM.

The part of the venous system contained within the skull consists of veins properly so called, and of certain channels called *sinuses*, which receive the blood from those veins, and conduct it to the internal jugular veins. The sinuses alluded to are spaces left between the layers of the dura mater, the fibrous covering of the brain.

CEREBRAL VEINS.

The veins of the brain are divisible into those which ramify upon its surface, and those which are placed within its ventricles.

The *superficial* veins upon the upper surface of the hemispheres are for the most part lodged in the tortuous sulci between the convolutions; but some run over the convexity of the convolutions. Their general direction is towards the middle line; and on reaching the margin of the longitudinal fissure between the hemispheres, they receive branches from the flat mesial surface of the hemispheres, and, becoming invested by tubular sheaths of the arachnoid membrane, incline obliquely forwards and open in that direction into the superior longitudinal sinus.

The veins upon the sides and under surface of the brain are directed outwards, to open into the lateral and other sinuses at each side.

The *deep* veins of the brain commence by branches within the ventricles of that organ. Upon the surface of the corpus striatum, for example, several small venous branches are seen, which for the most part converge to form a slender vein which runs along the groove between the corpus striatum and optic thalamus, and opens into one of the veins of the choroid plexus. The minute *veins* of the *choroid plexus* pass backwards, and incline towards the middle line from each side, so as to form, by their union, two veins—*venæ Galeni.* These, lying parallel, run directly backwards, enclosed within the velum interpositum, and escape from the interior by passing through the great transverse fissure of the brain between the under surface of the corpus callosum and the tubercula quadrigemina. In this way they reach the anterior margin of the tentorium cerebelli, at its place of union with the falx cerebri, where they terminate by opening into the straight sinus.

The *veins of the cerebellum* are disposed in two sets. Those of the upper surface incline inwards and forwards for the most part, and run upon the upper vermiform process, over which they ascend a little to reach the straight sinus, in which they terminate; some, farther forward, open

into the veins of Galen. Those at the under surface run transversely outwards, and pour their contents into the occipital and the lateral sinuses.

Fig. 312.

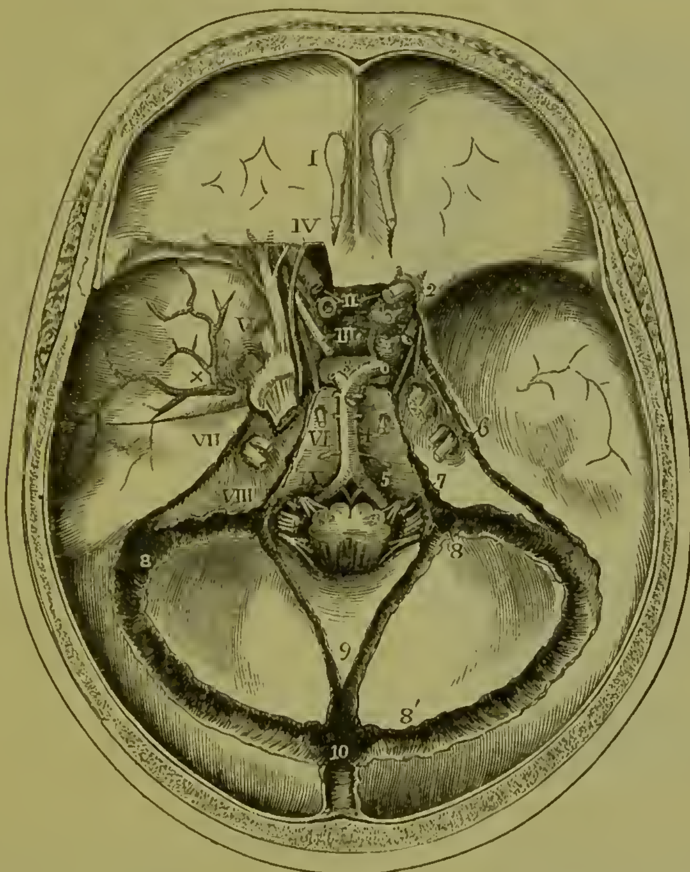


Fig. 312.—Internal View of the base of the Skull, showing the Sinuses of the Dura Mater, &c. ½

The sinuses of the dura mater have been opened, a small portion of the roof of the orbit has been removed posteriorly on the left side, and the dura mater has been dissected so as to bring into view the arteries at the base of the skull, the venous sinuses and the issue of the cerebral nerves.

I., the olfactory bulb; II., the optic nerves, that on the left side cut short; III., placed on the pituitary body, indicates the third nerve; IV., the trochlear nerve; V., placed opposite to the middle of the three divisions of the fifth nerve as they pass out of the cranium; VI., the sixth nerve; VII., the facial and auditory nerves entering the meatus auditorius internus; VIII., placed opposite to the three portions of the eighth pair as they pass into their several foramina of the dura mater; IX., the hypoglossal nerve as it passes to the anterior condyloid foramen; 1, the right internal carotid artery as it makes its turn in the cavernous sinus on the groove of the sphenoid bone; 2, its ophthalmic branch proceeding into the orbit, below and to the outside of the optic nerve; 3, division of the basilar artery into the two posterior cerebral arteries, one of which is represented on the right side as giving off the communicating artery to the internal carotid; 4, basilar artery; 5, vertebral arteries giving the anterior spinal; ×, great meningeal vessels spreading upwards from the foramen spinosum; 6, superior petrosal sinus; 7, inferior petrosal running back into the lower part of the lateral sinus; 8, termination of the lateral sinus in the internal jugular vein, and continuation of the lateral sinus; 8′, commencement of the lateral sinus; 9, occipital sinuses; 10, torcular Herophili, and below that number in the figure, the superior longitudinal sinus.

CRANIAL SINUSES.

The venous sinuses within the cranial cavity admit of being divided into

two sets, viz., those placed in the prominent folds of the dura mater, and those situated in the base of the skull.

Fig. 313.

Fig. 313. — Sketch of the internal veins of the Cranium and Nose. $\frac{1}{4}$

a, torcular Herophili; *b*, superior longitudinal sinus of the dura mater; *c*, inferior longitudinal sinus; *d*, straight sinus; *e*, internal veins of the brain, or veins of Galen; *g*, occipital sinus; *h*, superior petrosal sinus; *i*, inferior petrosal sinus; *k*, nasal veins on the septum; superiorly is shown the commencement from some of these of the superior longitudinal sinus, and lower down some of the nasal veins passing out by the spheno-palatine foramen.

The form and size of the sinuses are various. All of them are lined by a continuation of the internal membrane of the veins, the dura mater serving as a substitute for the other coats.

The sinuses which are contained in the several processes or folds of the dura mater converge to a common point, which corresponds with the internal occipital protuberance, and is called the *confluence of the sinuses*, or *torcular Herophili*. The form of the torcular is very irregular. Five or six apertures open into it: viz., one from the longitudinal, and one from the straight sinus; two from the right and left lateral sinuses; and one or two from the posterior occipital sinuses.

The *superior longitudinal sinus* (s. falciformis superior), commencing at the crista galli, extends from before backwards, in the upper border of the falx cerebri, gradually increasing in size as it proceeds. It is three-sided, and is crossed obliquely at the inferior angle by several bands, the *chordæ Willisii*. The veins from the cerebral surface open into this sinus chiefly towards the back part; and in such a way that the apertures of the greater number of them are directed from behind forwards, contrary to the direction of the current within it. The longitudinal sinus communicates with the veins on the outside of the occipital bone, by a branch (one of the "emissary veins," Santorini) which passes through a hole in the parietal bone.

The *inferior longitudinal sinus* (s. falciformis inferior) is very small, and so much resembles a cylindrical vein, that it is sometimes named *inferior longitudinal vein*. Placed in the inferior concave border of the falx cerebri, it runs from before backwards, and opens into the straight sinus on reaching the anterior margin of the tentorium cerebelli. It receives branches from the surface of the falx cerebri, and sometimes from the flat surface of the hemispheres.

The *straight sinus* (s. quartus; s. tentorii) runs backwards in the base of the falx cerebri, gradually widening as it approaches the torcular Herophili, in which it terminates. Besides the inferior longitudinal sinus, the venæ Galeni and the superior veins of the cerebellum open into it.

The *lateral sinuses* (s. transversi) are of considerable size. Their direction conforms to that of the groove marked along the inner surface of the occipital and other bones, and extending from opposite the internal occi-

pital protuberance to the foramen jugulare. The sinus of the right side is usually larger than that of the left; both commence at the torcular Herophili, and terminate in the jugular veins. The lateral sinuses receive the blood transmitted from both the longitudinal sinuses, from the straight and occipital sinuses, from the veins upon the sides and base of the brain, from those on the under surface of the cerebellum, and from some of the veins of the diploë. The petrosal sinuses also join the lateral sinus on each side: and two *emissary* veins connect these with the veins at the back of the head and neck.

Fig. 314.

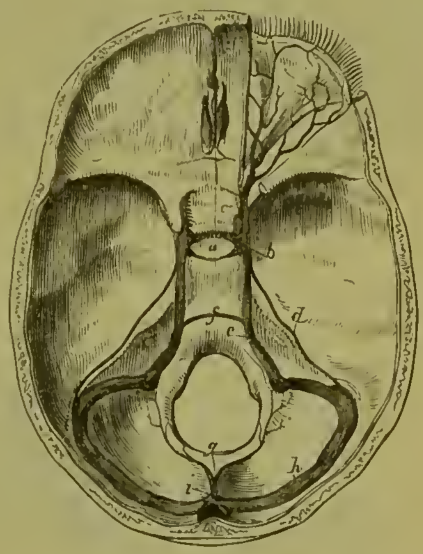


Fig. 314.—Sketch of the venous sinuses in the Base of the Cranium, with the Ophthalmic Vein.

a, sella turcica and circular sinus; *b*, cavernous sinus receiving *c*, the ophthalmic vein; *d*, superior petrosal; *e*, inferior petrosal sinus; *f*, transverse sinus; *g*, occipital; *h*, lateral; *i*, termination of the superior longitudinal in the torcular Herophili.

The *posterior occipital sinus* is sometimes a single canal, not unfrequently double, as if composed of two compartments. It lies along the attached border of the falx cerebelli, extending from the posterior margin of the foramen magnum to the confluence of the sinuses. It communicates in front with the posterior spinal plexuses of veins.

The sinuses placed at the base of the skull are as follows, taking them in their order from before backwards:

The *circular sinus* has the form of a ring, and is placed superficially in the margin of the dura mater round the pituitary body; it receives the blood from the minute veins of the pituitary body, and communicates at each side with the cavernous sinus. Sometimes it is only partially developed, the part in front of the gland being that usually present: sometimes, however, it is behind the gland.

The *cavernous sinuses* placed one on each side of the body of the sphenoid bone, over the bases of the great wings, and stretching from the sphenoidal fissure to the apex of the petrous portion of the temporal bones, are of considerable size, and of very irregular form. Each receives the ophthalmic vein at its fore part, and communicates internally with the circular sinus, and posteriorly with the petrosal sinuses. In the wall of each, separated by the lining membrane from the cavity of the sinus, pass forward the third, fourth, and sixth cranial nerves, the ophthalmic division of the fifth nerve, and the internal carotid artery.

The *upper petrosal sinus* is a narrow canal running along the upper margin of the petrous part of the temporal bone. Commencing at the back part of the cavernous sinus, it is directed outwards and backwards in the attached margin of the tentorium cerebelli; and descending a little, ends in the lateral sinus where this lies upon the temporal bone.

The *lower petrosal sinus*, wider than the upper, passes downwards and backwards along the inferior margin of the petrous bone, between this and

the basilar process of the occipital bone. It opens into the lateral sinus near the termination, or into the internal jugular vein.

The *anterior occipital* or *transverse sinus* (sinus basilaris) is placed at the fore part of the basilar process of the occipital bone, so as to establish a transverse communication between the opposite inferior petrosal and the cavernous sinuses.

OPHTHALMIC VEIN.

The ophthalmic vein opens into the cavernous sinus. Its branches are distributed in the different structures contained within the orbit, in company with the branches of the ophthalmic artery : some small ramifications arise from the eyelids, whilst others communicate with the angular branch of the facial vein ; and those which accompany the supraorbital artery have similar connections with the veins upon the forehead. All these branches, together with others arising from the lachrymal gland, from the different muscles, from the ethmoidal cells, and from the globe of the eye, severally

Fig. 315.

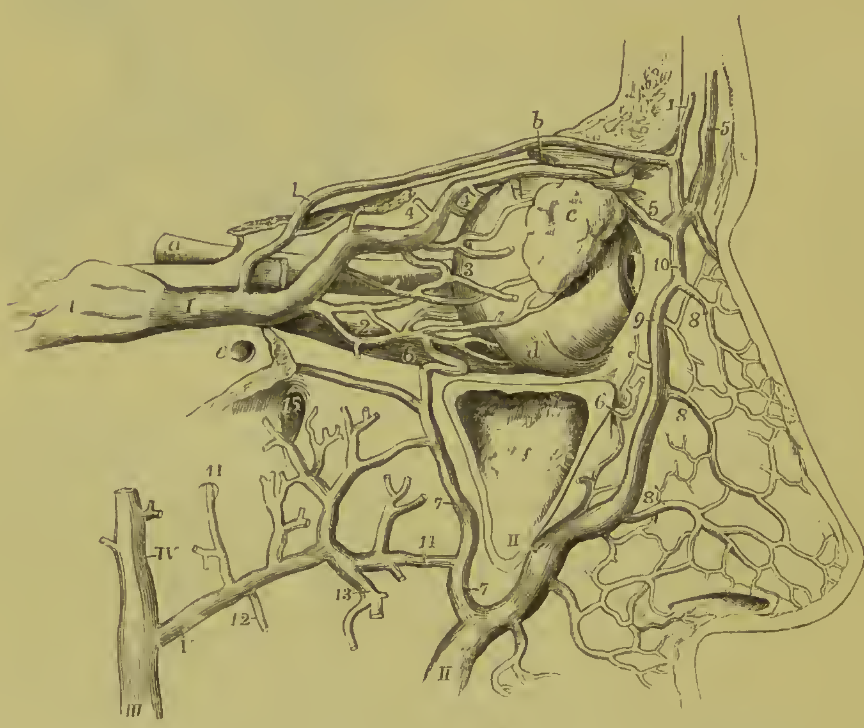


Fig. 315.—Sketch of the Ophthalmic Vein, and of its Distribution and Communication with other Veins (altered from Hirschfeld and Leveillé).

The orbit is opened from the outer side and the dissection is similar to that for displaying the ophthalmic artery (represented in Figure 260, at p. 361) ; *a*, the optic nerve before it enters the optic foramen ; *b*, the superior oblique muscle divided before it passes through its pulley ; *c*, the lachrymal gland lying upon the eyeball ; *d*, the insertion of the inferior oblique muscle ; *e*, foramen rotundum ; *f*, sinus maxillaris, opened externally ; I, the ophthalmic vein joining the cavernous sinus ; 1, supraorbital branch ; 2, muscular and lachrymal branches ; 3, ciliary ; 4, anterior and posterior nasal or ethmoid, ; 5, frontal ; 6, infraorbital ; II, facial vein ; 7, communication with the internal maxillary ; 8, external nasal ; 9, angular, communicating at 10, with the frontal and supraorbital ; III, external jugular vein commencing at the junction of IV, the temporal and V, the internal maxillary veins ; 11, meningeal branch ; 12, inferior dental ; 13, muscular ; 14, communication between the facial, malar and infraorbital ; 15, placed in the spheno-maxillary fossa above branches connected with the pterygoid plexus.

named according to the arterial branches which they accompany, join to form a short single trunk, which leaves the orbit by the inner part of the sphenoidal fissure, where it is placed between the heads of the external rectus muscle, and terminates in the cavernous sinus.

Not unfrequently one of the frontal veins is much larger than the others, and descending vertically near the middle of the forehead, joins the facial and a branch of the ophthalmic vein on one side of the root of the nose.

VEINS OF THE DIPLOË.

The veins of the diploë of the cranial bones are only to be seen after the pericranium is detached, and the external table of the skull carefully removed by means of a file. Lodged in canals hollowed in the substance of the bones, their branches form an irregular network, from which a few larger vessels issue. These are directed downwards at different parts of the cranium, and terminate, partly in the veins on the outer surface of the bones, and partly in the sinuses at the base of the skull.

Fig. 316.

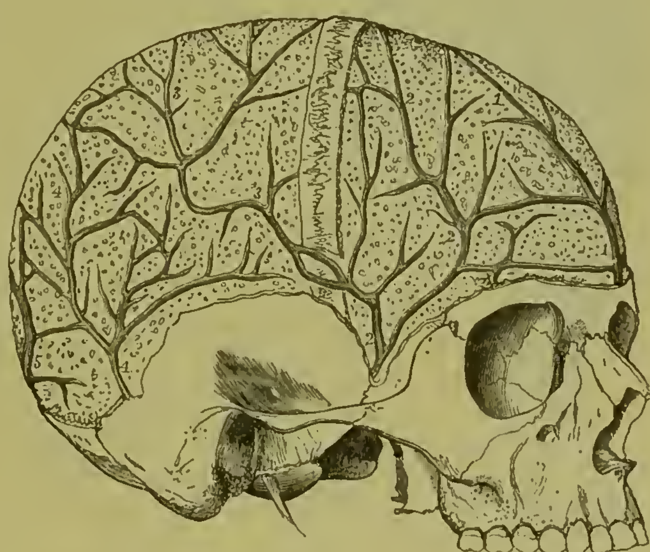


Fig. 316. — Veins of the Diploë of the Cranial Bones (after Breschet). $\frac{1}{3}$

The external table has been removed from the greater part of the calvarium so as to expose the diploë and the veins which have been injected. 1, a single frontal vein; 2, 3, the anterior temporal vein of the right side; 4, the posterior temporal; 5, the occipital vein of the diploë.

According to Breschet there are four such veins on each half of the cranium, viz., a frontal, occipital, and two temporal.

The *frontal* is small, and issues by an aperture at the supra-orbital notch to join the vein in that situation. There is often only one frontal vein present.

The *temporal* are distinguished as anterior and posterior. The anterior is contained chiefly in the frontal bone, but may extend also into the parietal, and opens into the temporal vein, after escaping by an aperture in the great wing of the sphenoid. The posterior ramifies in the parietal bone, and passes through an aperture at the lower and hinder angle of that bone to the lateral sinus.

The *occipital* is the largest of all; and leaves the occipital bone opposite the inferior curved line to open, either internally or externally, into the occipital sinus or the occipital vein. Its ramifications are confined especially to the occipital bone.

VEINS OF THE UPPER LIMB.

The veins of the upper limb are divisible into two sets, the superficial, and the deep-seated. Both sets are provided with valves, and these are

more numerous in the deep than in the subcutaneous veins. Valves are constantly to be found at the entrance of branches into the main vessels.

SUPERFICIAL VEINS OF THE UPPER LIMB.

The superficial veins of the upper limb are much larger than the deep; they lie between the skin and the fascia. At the upper part of the fore

Fig. 317.

Fig. 317.—SKETCH OF THE SUPERFICIAL VEINS OF THE ARM AND FOREARM FROM BEFORE. $\frac{1}{8}$

1, biceps muscle; *a*, radial veins; *b*, cephalic vein; *c*, ulnar veins; *d*, some of the posterior ulnar veins; *e*, basilic vein dipping below the fascia; *f*, median vein; *g*, median basilic; *h*, median cephalic.

arm they are most frequently collected into three trunks, the *radial*, *ulnar*, and *median* veins. At the bend of the elbow the median vein divides into an outer and an inner vessel, named respectively *median-cephalic* and *median-basilic*, one of which joins with the radial to form the *cephalic* vein, while the other joins with the ulnar to form the *basilic*. The two principal cutaneous veins of the forearm, the radial and the ulnar, commence on the dorsal surface of the hand, by a sort of plexus, formed by the convergence of numerous small veins, which proceed from the dorsal surface of the fingers.

The *radial cutaneous* vein commences by branches upon the dorsal surface of the thumb and fore finger. These ascend over the outer border of the wrist, and form by their union a large vessel, which passes along the radial border of the forearm, receiving numerous branches from the anterior and posterior surfaces. At the bend of the arm, in the groove external to the biceps muscle, it unites with the median-cephalic division of the median vein, to form the cephalic vein.

The *cephalic* vein ascends along the outer border of the biceps muscle and in the interval between the great pectoral and deltoid muscles, and finally, dipping in between those muscles, terminates in the axillary vein, between the coracoid process and the clavicle.

The *ulnar cutaneous* veins are two in number, one on the front, the other on the back part of the forearm. The *posterior* ulnar cutaneous vein, begins on the back of the hand by branches, which unite to form a vein placed over the fourth metacarpal space, and called by some of the older anatomists "vena salvatella." This proceeds along the ulnar border of the forearm on the posterior aspect, and, below the bend of the elbow, turns forwards to join with the *anterior* ulnar cutaneous vein, which ascends from the anterior surface of the wrist. At the bend of the elbow, the common ulnar cutaneous unites with the median-basilic division of the median to form the basilic vein.

The *basilic* vein, usually of considerable size, ascending along the inner border of the biceps muscle, in front of the brachial artery, passes through

the fascia below the middle of the arm, and finally unites with one of the venæ comites of that vessel, or with the axillary vein, which it chiefly forms.

Fig. 318.

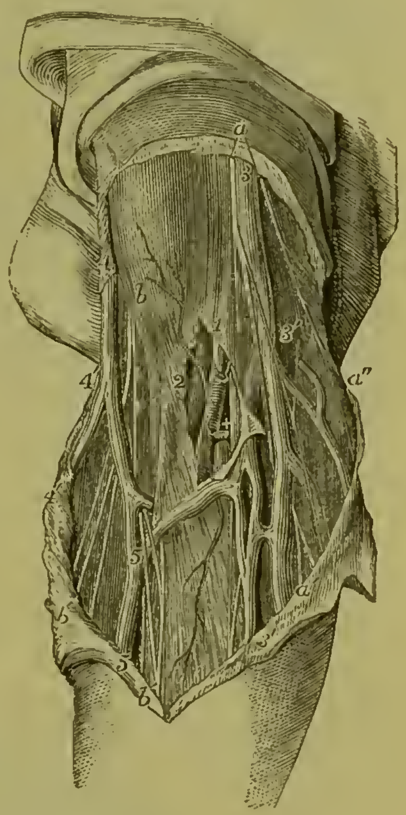


Fig. 318.—View of the Superficial Veins at the bend of the Arm (from R. Quain). ½

The full description of this figure will be found at p. 383. The following numbers indicate the veins:—At 1 and 2, the fascia is opened in front of a part of the brachial artery and its accompanying veins; the inner vena comes, marked 1, has been divided, the outer marked 2, is entire; +, the median nerve; 3, the basilic vein; 3′, the ulnar veins; 4, the cephalic vein; 4′, one of the radial veins; 5, the median vein; 5 to 4′, median cephalic; 5 to 3′, median basilic.

The *median cutaneous* vein results from the union, on the anterior part of the forearm, of several branches. It is a short trunk of variable length, which ascends between the ulnar and radial cutaneous veins on the front of the forearm, and terminates beneath the hollow in front of the elbow by dividing into the median-basilic and median-cephalic branches which diverge upwards from each other. Close to its bifurcation it receives a short branch, the *deep median* vein, which pierces the fascia to meet it, and forms a communication between it and the deep veins accompanying the arteries.

The *median-basilic* vein, inclining inwards to join the basilic vein, passes in front of the brachial artery, from which it is separated by the fibrous expansion given by the tendon of the biceps muscle to the fascia covering the flexor muscles; it is crossed by branches of the internal cutaneous nerve.

The *median-cephalic* vein, directed outwards, unites with the cephalic vein. Branches of the external cutaneous nerve descend behind it.

DEEP VEINS OF THE UPPER LIMB.

The brachial artery and its various branches in the arm, forearm, and hand, are each accompanied by two veins, named *venæ comites.* These companion veins lie one on each side of the corresponding artery, and are connected with each other at intervals by short cross branches, which in some places surround the artery. Their distribution so closely corresponds with that of the arteries that they need not be more particularly described.

The *brachial veins*, or *companion veins* of the brachial artery, terminate at the lower margin of the subscapularis muscle by joining the axillary vein; not unfrequently, however, one of them will be found to come forward and unite with the basilic, which soon after becomes continuous with the axillary vein.

Between the several veins of the upper limb numerous communications

exist in their whole course. Thus, those which lie beneath the integument are connected to each other by branches in the hand and forearm. The veins in each pair of venæ comites are also united by short transverse vessels crossing the artery which they accompany, whilst between those attending different arteries frequent connections exist. Lastly, the subcutaneous and the deep veins communicate freely, especially in the neighbourhood of joints. This general anastomosis ensures the continuance of the circulation during muscular action in the frequent and varied motions of the limb.

AXILLARY VEIN.

The *axillary vein* returns all the blood from the upper limb : its size is very considerable, and it is the highest of the veins of the upper limb in which valves are constantly found. It extends, like the corresponding artery, from the lower border of the axilla to the outer margin of the first rib ; it is covered by the pectoral muscles and the costo-coracoid membrane, and is placed to the inner side of the axillary artery. It is continuous below with the basilic vein of the arm, either alone or in conjunction with one of the deep brachial veins.

Fig. 319.

Fig. 319.—View of the Bloodvessels of the Right Axilla and Arm from the inner side (from R. Quain). $\frac{1}{4}$

The detailed description of this figure will be found at p. 382. The following numbers indicate the principal veins :—2, the axillary vein ; 3, basilic vein ; 3′, median basilic ; 4, 4′, cephalic vein joining the acromial thoracic and axillary ; 6, alar-thoracic and subscapular ; 7, one of the brachial veins.

Tributaries.—The axillary vein receives the subcutaneous veins of the arm, viz. the basilic at its commencement, the cephalic towards its termination ; and between these the companion veins of the brachial artery ; it is also joined by the several veins corresponding with the branches of the axillary

artery, viz., the two *circumflex* and the *subscapular* veins from the shoulder, the *alar* vein from the axilla, and the inferior, superior, and acromial *thoracic* veins from the side of the chest.

SUBCLAVIAN VEIN.

The *subclavian vein* is the continuation of the axillary, but is not like it constantly provided with valves, although a pair may often be found near its termination (Struthers, loc. cit.). It extends from the outer margin of the first rib to the inner end of the clavicle, behind which it terminates by joining with the internal jugular vein to form the innominate or brachio-cephalic vein. The subclavian vein crosses over the first rib and behind the clavicle, not reaching so high up in the neck as the subclavian artery ; it is covered by the clavicle, and by the subclavius and sterno-mastoid muscles, and lies on a plane anterior to the artery, from which, while resting on the rib, it is separated by the scalenus anticus muscle and the phrenic nerve.

TRIBUTARIES.—(*a*). The *external* and *anterior jugular* veins (p. 459) open into the subclavian vein on the outer side of the scalenus anticus muscle.

(*b*). The *vertebral vein*, commencing in branches which proceed from the pericranium and the deep muscles lying behind the foramen magnum of the occipital bone, passes outwards and downwards to reach the intertransverse foramen of the atlas. Through this foramen, and through the canal formed by the corresponding foramina of the other cervical vertebræ, the vein descends with the vertebral artery. Emerging at the foramen in the sixth vertebra, it runs forwards and downwards to join the subclavian vein close to the termination : a small branch sometimes descends through the foramen in the seventh vertebra, and opens separately into the subclavian. The vertebral vein is joined in its course by several branches from the neighbouring muscles ; also, immediately before its termination, by a branch corresponding with the deep cervical artery ; and in the same situation by another branch of considerable size, which descends in front of the bodies and transverse processes of the vertebræ of the neck, and may be termed the external vertebral vein. It communicates frequently with the spinal veins in the neck, both those on the outer side, and those in the interior of the spinal canal.

AZYGOS VEINS.

The azygos veins are longitudinal vessels formed by the union of the veins corresponding to the arteries of the intercostal spaces, and are placed on the sides of the spine. In the lower part of the thorax the two veins of opposite sides are disposed symmetrically, but higher up the blood gathered from some of the veins of the left side is poured into the trunk on the right, which becomes enlarged and unsymmetrical, and has on that account received the name of azygos, while the united lower veins from the corresponding parts on the left side constitute the small or left azygos.

The *azygos*, or *right azygos* vein (vena sine pari), commences sometimes by a small branch derived from the inferior cava, where that vessel turns forwards to reach its opening in the diaphragm ; but much more frequently it begins below from the lumbar veins (ascending lumbar) of the right side, and sometimes from the renal vein. Passing from the abdomen into the thorax through the aortic opening in the diaphragm, or to the outer side of

that opening through the fibres of the diaphragm, the azygos vein ascends

Fig. 320.

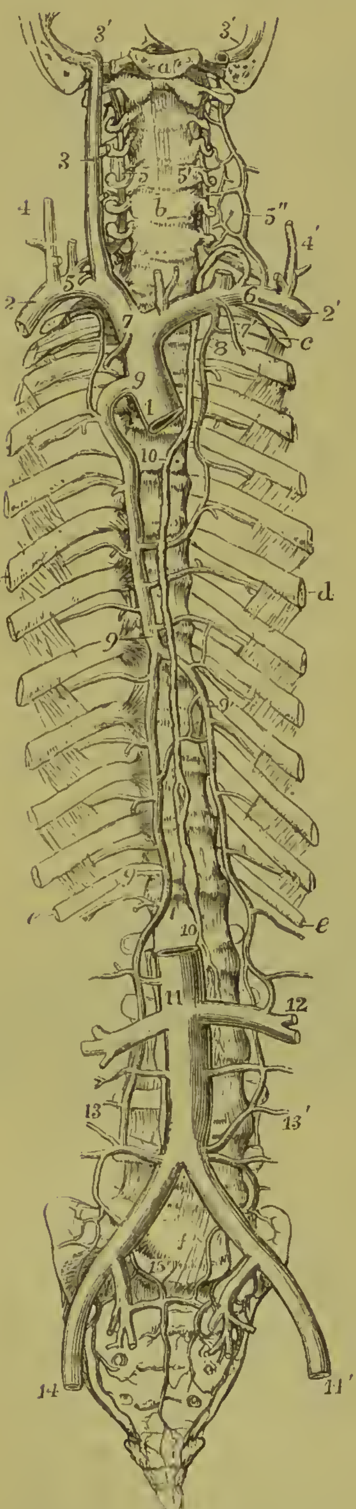


Fig. 320.—Sketch of the Principal Systemic Venous Trunks, the Azygos, and Intercostal Veins.

For the detailed description of this figure see p. 454. The following indications relate to the accompanying part of the text:—8, the right, 8', the left, superior intercostal veins; 9, the main trunk of the azygos vein; the uppermost number marks its junction with the superior cava, the lowest its passage into the abdomen; 9', the left or hemiazgyos; 10, thoracic duct; 11, inferior vena cava; 12, the union of a branch of the left azygos with the left renal vein; 13, 13', the right and left azygos veins continued down into the abdomen, and joining some of the lumbar veins; 15, union of lumbar, ilio-lumbar, and sacral veins.

on the bodies of the dorsal vertebræ, until it arrives opposite the root of the right lung, over which it arches forwards, and then opens into the upper vena cava, immediately above the point at which that vessel is invested by the pericardium. When passing through the opening in the diaphragm, this vein is accompanied by the thoracic duct, both being situated on the right side of the aorta. In the thorax, maintaining the same position with respect to the duct and the œsophagus, it passes in front of the intercostal arteries, and is covered by the pleura. It is joined by the several veins which accompany the aortic intercostal arteries of the right side; and at about the sixth or seventh dorsal vertebra, by the left or smaller azygos vein. It is also joined by several œsophageal and other small veins, and near its termination by the bronchial vein of the right lung; and it is generally connected with the right superior intercostal vein. As it communicates below with the vena cava inferior through one of the branches of that large vein, while it terminates above in the vena cava superior, it forms a connection between those two vessels. A few valves of imperfect formation have been found in the azygos vein; its branches (intercostal veins) are provided with distinct valves.

On the left side of the chest the veins of the three or four upper intercostal spaces are usually united into one trunk, forming the left superior intercostal vein, which (as already mentioned at

p. 455) is most frequently united with the left innominate vein, but sometimes is connected with the main azygos vein.

Of the remaining left intercostal veins, one or two, generally about the fifth and sixth, pass directly into the azygos; while the lowest in greater number unite almost constantly into one trunk, forming the left or small azygos, which crosses to join the main azygos in the neighbourhood of the seventh dorsal vertebra. There is frequently union between these three sets of veins or their intercostal branches, so that a part of one may be replaced by another, and the relative size of the veins may be subject to considerable variation.

The *left lower* or *small azygos* vein (vena hemiazygos) commences from one of the lumbar veins (ascending lumbar), or from the left renal vein, and having entered the thorax with the aorta, or through the crus of the diaphragm, ascends upon the spine in front of the left intercostal arteries, receiving the lower intercostal veins of the left side; and passing behind the aorta, it opens into the right azygos vein, opposite the sixth or seventh dorsal vertebra.

The azygos vein has been seen to receive the lower vena cava, and, in such cases, is of course extremely large.

In one instance, Meckel found the azygos ending in the subclavian vein.

All the intercostal veins of the left side have been observed in some instances to join a single vein, which ended in the left innominate; the arrangement corresponding with that on the right side of the body.

The *bronchial veins* return the blood employed in the nutrition of the lungs. Their course corresponds with that of the bronchi, which support them as they pass towards the root of the lungs. The bronchial vein of the right side opens into the trunk of the azygos vein near its termination, that of the opposite side ends in the superior intercostal vein.

VEINS OF THE SPINE.

The spinal veins form plexuses of closely anastomosing vessels along the whole length of the spinal column. They have no valves.

The veins within and upon the spinal column may be distinguished into the following sets: *a.* The dorsal, placed deeply in the vertebral grooves, and resting upon the spines and arches of the vertebræ. *b.* The veins lodged within the bodies of the vertebræ. *c.* The anterior longitudinal, two long series of veins, or rather venous plexuses, extended behind the bodies of the vertebræ in the whole length of the canal. *d.* The posterior longitudinal veins, situated within the canal on the fore part of the arches of the vertebræ. *e.* The veins of the spinal cord. There are likewise branches of communication, some of which connect all the other sets together, and some which bring them into connection with the general venous system. (Breschet, "Essai sur les Veines du Rachis," 4to; "Traité Anatomique sur le Système Veineux," fol., 1829; Cloquet, "Traité d'Anatomie descriptive," &c.)

a.—The *dorsal veins.* The blood from the muscles and integument along the back of the spine is returned by a series of short veins, which ramify upon the arches and spinous processes of the vertebræ. They run forwards close to the spinous processes, and on reaching the interval between the arches of the vertebræ, pierce the ligamenta subflava, and terminate in a venous plexus within the canal. Towards the outer part of the intervertebral grooves other veins arise, which pass obliquely forwards, through the intertransverse spaces, in company with the posterior branches of the lumbar

and intercostal arteries, and open into the veins which accompany those vessels.

b.—The *veins belonging to the bodies of the vertebræ* (venæ basis vertebrarum,—Dupuytren) are comparatively large vessels contained in the canals within the bodies of the vertebræ; the arteries which accompany them being very small. They anastomose on the front of the bones with some of the superficial veins; and the trunk of each, having reached the spinal canal through the foramen in the posterior surface of the body of the vertebra, divides into two branches, which diverge and terminate in the large spinal veins behind the bodies of the vertebræ.

c.—The *anterior longitudinal spinal veins.*—The blood collected by the different vessels here described is poured into two large veins, or rather tortuous venous canals, which extend, one on each side, along the whole length of the spinal canal behind the bodies of the vertebræ. These vessels (the great spinal veins of Breschet) are alternately constricted and enlarged, the constricted points corresponding with the intervertebral foramina, where they are drawn forwards, and bound down by the branches of communication which pass outwards. In some parts the veins are double, or even triple, so as to form a plexus, and occasionally they are altogether interrupted. In the thoracic region their communicating branches open into the intercostal veins, in the loins into the lumbar veins, in the neck for the most part into the vertebral.

Fig. 321.

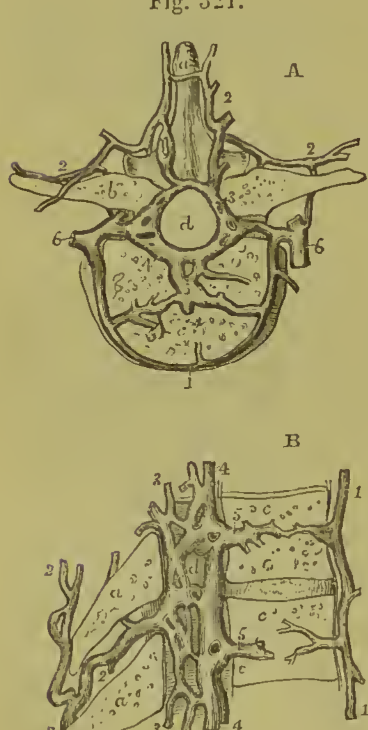


Fig. 321, A and B.—HORIZONTAL AND VERTICAL SECTIONS OF THE LOWER DORSAL VERTEBRÆ, SHOWING THE EXTERNAL AND INTERNAL VEINS OF THE SPINE (after Breschet). §

a, spinous process; *b*, transverse process; *c*, body; *d*, spinal canal; 1, anterior external veins of the body; 2, posterior external veins of the vertebral column communicating with the internal and forming a plexus over the laminæ and processes; 3, the posterior, and 4, the anterior internal plexus of veins of the vertebral canal; 5, the internal veins of the body joining the internal spinal veins; 6, the lateral veins, which are joined by the internal and external spinal veins, and themselves unite with the intercostal.

d. The *posterior longitudinal spinal veins* are a complex interlacement of tortuous veins along the inner or anterior surface of the arches of the vertebræ. In the lower part of the canal this interlacement of veins is not so close as in the upper portion, where it usually conceals (if the injection has been successful) the whole surface of the dura mater. These veins converge to the intervertebral foramina, and join by rather small vessels with the intercostal veins.

e.—The *veins of the spinal cord* (Breschet) ramify upon the cord and its nerves, enclosed within the sheath formed by the dura mater. Though they communicate with the other spinal veins, they are not injected with them, even when the injecting process is most successful. Very small,

long, and tortuous, they run upon both surfaces of the cord, and form a diffused network. They become larger, for the most part, as they ascend, but near the base of the skull they are smaller than in the lumbar region. They communicate freely with the spinal veins and plexuses, by means of branches which accompany the nerves towards the intervertebral foramina. Near the base of the skull they unite to form two or three small trunks, which communicate by transverse branches with the vertebral veins, and terminate in the inferior cerebellar veins, or in the petrosal sinuses.

From a consideration of the connection and arrangement of the different parts of these complex veins, it would appear that the main currents of the blood in each part flow through them horizontally. The dorsal veins pour their blood into the longitudinal plexus on the inner surface of the arches of the vertebræ; thence it is collected, at each of the intervertebral foramina, by two or three small converging branches, which open into some of the veins outside the vertebral column in front, viz., into the lumbar, azygos, and cervical veins. Into these, also, the contents of the great spinal veins are conveyed by the short communicating branches already noticed.

LOWER VENA CAVA.

The *lower* or *ascending vena cava* returns the blood from the lower limbs, and from the viscera of the pelvis and abdomen. It commences at the junction of the two common iliac veins on the side of the fifth lumbar vertebra, and thence ascends along the right side of the aorta, as far as the posterior border of the liver; it there becomes lodged in a groove in that organ, after which it inclines forwards to reach the opening in the diaphragm appropriated to it, and, after being enclosed in a fold of the pericardium, terminates in the right auricle of the heart. A large valve is situated at its entrance into the auricle, named the valve of Eustachius, which, however, as already explained in the description of the heart, is only a vestige of fœtal structure, variable in size, and without influence in preventing reflux of the blood.

Tributaries.—Besides the common iliac veins, the inferior vena cava receives the following:—

a.—The *middle sacral* vein, taking its course upwards on the front of the sacrum, opens into the left common iliac vein, or into the commencement of the vena cava.

b.—The *lumbar* veins correspond in number with the arteries of the same name: they commence by small *dorsal* branches in the muscles of the back; and by others from the walls of the abdomen, where they communicate with the epigastric and other veins in the neighbourhood. Having reached the spine, they receive branches from the *spinal* plexuses, and proceed forward upon the bodies of the vertebræ, behind the psoas muscle: those on the left side, passing behind the aorta, terminate in the back of the vena cava. Some of these veins are frequently found to unite into a single trunk before their termination. The lumbar veins of the same side communicate with each other by branches which cross in front of the transverse processes. Not unfrequently a branch of this description is met with, called the *ascending lumbar* vein, which connects more or less completely the common iliac vein, the ilio-lumbar and lumbar veins, and the azygos vein.

c.—The *spermatic* veins, proceeding upwards from the testicle and forming a part of the constituents of the spermatic cord, enter the abdomen, and ascend on the psoas muscle behind the peritoneum. Below the

abdominal ring there are numerous convoluted branches forming the *spermatic plexus* (plexus pampiniformis). These branches gradually unite, and form a single vessel, which opens on the right side into the lower vena cava, and on the left into the renal vein. The spermatic veins sometimes bifurcate before their termination, each division opening separately ; in this case, the veins of the right side may be found communicating with the vena cava and the renal vein.

In the female the *ovarian* veins have the same general course as the ovarian arteries ; they form a plexus near the ovary (ovarian or pampiniform plexus) in the broad ligament, and communicate with the uterine plexus.

Valves exist in the spermatic veins in man (Monro) ; and, in exceptional cases, they have been also seen in the ovarian veins (Theile).

d.—The *renal* or *emulgent* veins are short, but of very considerable size. That of the left side is longer than that of the right, and passes in front of the aorta. They join the vena cava at nearly a right angle. The renal veins usually receive branches from the suprarenal capsules ; the left has also opening into it the spermatic vein of the same side.

e.—The *capsular* or *suprarenal* veins, though actually small, are, relatively to the organs from which they arise, of considerable size. On the right side the vein ends in the vena cava, and on the left in the renal or phrenic vein.

f.—The *phrenic* veins follow exactly the course of the arteries supplied to the diaphragm by the abdominal aorta.

g.—The *hepatic veins* return from the liver the blood sent to that organ by the portal vein and hepatic artery. They converge to the groove in which the inferior vena cava lies, and pass at once obliquely into that vein. There are usually three sets of hepatic veins proceeding to this common point : those from the right and left lobes are oblique in their direction, those from the middle of the liver and the lobule of Spigelius have an intermediate position and course. The hepatic veins have no valves ; but, owing to their oblique entrance into the vena cava, a semi-lunar fold is seen at the lower border of the orifice of each vein.

Peculiarities.—The lower vena cava presents some occasional deviations from its ordinary condition, which may be briefly noticed.

In the lower part of its course, it is sometimes placed to the left side of the aorta, and, after receiving the left renal vein, resumes its ordinary position by crossing over the great artery. Less frequently, the vena cava is placed altogether on the left side, and is continued upwards to the heart, without any change in its direction : this occurs in cases of transposition of the thoracic and abdominal viscera and of the great vessels.

In a more numerous class of cases, the left common iliac vein, instead of joining the right in its usual position, is connected with it only by a small branch, and then ascends on the left side of the aorta. After receiving the left renal vein, it crosses over the aorta, and terminates by uniting with the common iliac vein of the right side. In these cases, the vena cava inferior can be said to exist only at the upper part of the abdomen, and below this point there is a vein on each side of the aorta.

Lastly, the lower vena cava, instead of ending in the right auricle of the heart, has been seen to join the right azygos vein, which is then very large ; so that the blood from the lower, as well as from the upper part of the body, is returned to the heart through the upper vena cava. In this case, the hepatic veins do not join the lower cava, but pass directly into the right auricle, at the usual place of termination of the great vein.

The left renal vein has been seen to cross behind the aorta.

In a remarkable case, observed by Rothe, one of the hepatic veins ended, not in

the lower cava, nor in the right auricle, but in the right ventricle of the heart, its orifice being guarded by valves. (Act. Acad. Joseph. Med. Chir. Vindobonensis, t. i. p. 233, tab. 5. Vindobonæ, 1788.)

VEINS OF THE LOWER LIMB AND PELVIS.

The veins of the lower limb are divisible into two sets, those of one being deeply seated, those of the other running in the superficial fascia. All the veins of the lower limb, as high as the femoral venous trunk, are provided with valves, and these are more numerous than in the veins of the upper limb. The deep veins have more valves than the subcutaneous set.

Fig. 322.

Fig. 322.—Outline of the Superficial Veins of the Lower Limb.

1, the saphenous aperture of the fascia lata; *a*, superficial epigastric vein; *b*, external pudic; *c*, superficial circumflex iliac; *d*, external or short saphenous beginning on the dorsum of the foot (see Fig. 326).

SUPERFICIAL VEINS OF THE LOWER LIMB.

Immediately beneath the integument, on the dorsum of the foot, there exists a network of veins forming an arch, from which issue two principal trunks, which are named the internal or long and the external or short saphenous veins.

The *internal* or *long saphenous* vein extends from the ankle to within an inch and a half of Poupart's ligament. Taking rise from the plexus of veins on the dorsum of the foot, it passes upwards in front of the inner ankle, and along the inner border of the tibia, accompanied by the internal saphenous nerve. It inclines a little backwards as it passes the inner condyle of the femur, and ascending along the inner and fore part of the thigh, it terminates in the femoral vein, at the *saphenous opening* in the fascia lata, through which it passes.

In the leg it communicates with the deep veins accompanying the anterior and posterior tibial arteries, and in the thigh one or more branches pass between it and the femoral vein. This long vein has a variable number of valves. Sometimes six have been counted; in other cases only four, or even two. It contains more in its course through the thigh than in the leg.

Tributaries.—The long saphenous vein is joined in its course by numerous cutaneous vessels. Close to its termination it receives, besides a considerable *anterior* branch, the *superficial epigastric*, *external pudic*, and *superficial circumflex iliac* veins, corresponding severally to arterial branches of the same name.

It is also usually joined near its termination by a *posterior* branch of considerable size, coming from the posterior and inner part of the thigh.

The *external* or *short saphenous* vein proceeds from branches, which arise along the outer side of the dorsum of the foot. It passes behind the

Fig. 323.

Fig. 323.—Outline of the Posterior or Short Saphenous Vein.

The vein, commencing on the dorsum and outside of the foot, is seen to pass up behind the outer ankle and to dip beneath the fascia in the popliteal space.

outer ankle, and gradually inclines backwards to ascend along the border of the tendo Achillis and on the belly of the gastrocnemius muscle, accompanied by the external saphenous nerve; running upwards between the heads of the gastrocnemius, it unites with the popliteal vein. Opposite the ankle and along the leg it communicates with the deep veins : and it receives superficial accessory veins from the outer part of the foot and the back of the leg.

THE DEEP VEINS OF THE LOWER LIMB.

The deep veins accompany the arteries and their branches, following exactly their distribution. Those below the knee, being for the most part disposed in pairs, and presenting the disposition described in the corresponding veins of the upper limb, are named the *venæ comites* of the vessels with which they are associated. The venæ comites of the arteries of the leg, namely, the *anterior* and *posterior tibial* veins (the latter having previously received the *peroneal*), unite near the lower border of the popliteus muscle, and form by their junction the popliteal vein. The valves of the deep veins of the leg are very numerous,—ten or twelve being sometimes found between the heel and the knee.

The popliteal vein, thus formed, receives smaller branches corresponding with the articular and muscular arteries, and the larger branch named the external saphenous vein. In its course through the ham, the popliteal vein is placed at first internal to the popliteal artery, then behind, and lastly to the outer side of it, but always posteriorly and between it and the nerve. Thus situated, it passes up through the aperture in the adductor magnus, and becomes continuous with the femoral vein.

Peculiarities.—The union of the veins which form the popliteal is often farther up than usual, and the lower part of the artery is accompanied by two veins. This arrangement in some rare cases extends to the entire length of the artery.

The femoral vein extends, like the artery which it accompanies, through the upper two-thirds of the thigh, and terminates at Poupart's ligament in the external iliac vein. Placed at first outside the artery, it gradually inclines inwards behind it, and on reaching Poupart's ligament, lies on the inner side, on the same plane with the artery, and separated from it only by a slight partition of the membranous sheath, by which they are both invested.

In the lower part of its course, the vein receives all the branches which accompany the offsets of the chief artery. In the upper part, the deep femoral vein opens into it, having first received all the branches from muscles supplied by the deep femoral artery. Near its termination the femoral vein is joined by the internal saphenous vein.

Fig. 324.

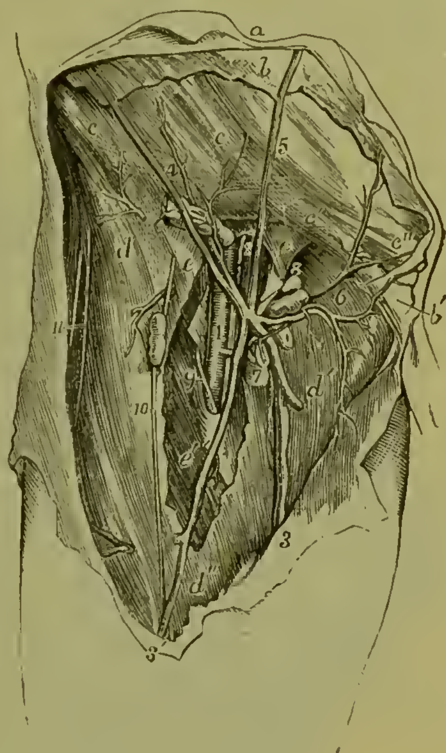


Fig. 324.—View of the Blood-vessels of the Groin and neighbouring parts (from R. Quain). $\frac{1}{4}$

The full description of this figure will be found at p. 436. The following numbers indicate the veins :—2, the femoral vein ; 3, the large or internal saphenous vein; 3′, anterior saphenous ; 4, superficial circumflex veins with twigs to the inguinal glands ; 5, superficial epigastric ; 6, superficial pudic.

The femoral vein occasionally pursues a course different from that of the artery along the thigh. Extending upwards from the popliteal space, the vein in such cases perforates the adductor magnus above the ordinary position, and joining with the deep femoral vein first approaches the femoral artery at the groin. The same vein is sometimes double in a small part, or more rarely in almost its whole length.

EXTERNAL ILIAC VEIN.

The external iliac vein is the continuation of the femoral vein from Poupart's ligament to the junction of the internal iliac vein, in the neighbourhood of the sacro-iliac articulation. It is at first internal to the artery, and on the left side it continues in that position, but on the right side it gradually inclines somewhat behind the artery. It does not possess valves.

Tributaries.—Near its commencement at Poupart's ligament, the external iliac vein receives the *circumflex iliac* and the *epigastric* veins.

INTERNAL ILIAC VEIN.

The internal iliac vein is formed by the union of branches which accompany the corresponding branches of the internal iliac artery. The umbilical vein of the fœtus, however, which in the cord accompanies the corresponding arteries, diverges from these arteries within the body, and passes upwards to the liver. The internal iliac vein lies behind the corresponding artery in front of the sacro-iliac articulation, and, after a short course upwards to the margin of the pelvis, joins with the external iliac vein to form the common iliac. No valves are found in the trunk of the internal iliac vein, but they exist in its branches.

TRIBUTARIES.—The tributaries of the internal iliac vein correspond in general to the various branches of the internal iliac artery, with the exception that the internal pudic vein does not receive the main supply of blood from the dorsal vein of the penis. The visceral veins are remarkable for their size and frequent anastomoses, and have been described as forming a series of plexuses, severally named the *vesical*, *prostatic*, *hæmorrhoidal*, *uterine*, and *vaginal*.

Fig. 325.

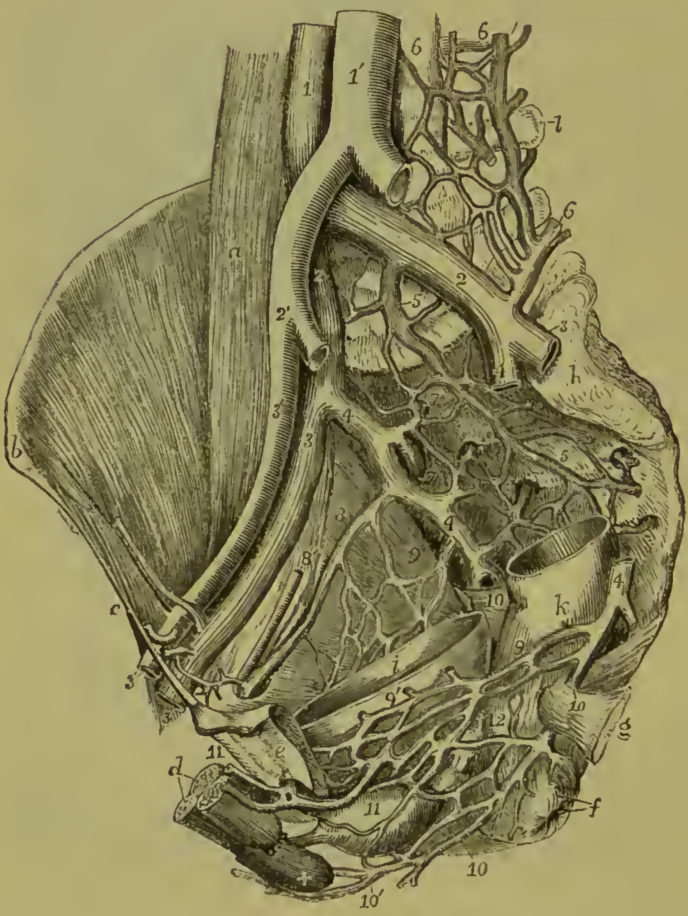


Fig. 325.—INTERNAL VIEW OF THE MALE PELVIS FROM THE LEFT SIDE, TO SHOW THE PRINCIPAL VEINS. $\frac{1}{3}$

The greater part of the os innominatum and pelvic wall of the left side, and the upper parts of the rectum and urinary bladder, have been removed: the left common iliac and the right internal iliac arteries, and the left external and internal iliac veins, have been cut short. *a*, the right psoas magnus muscle; *b*, the anterior superior iliac spine; *c*, Poupart's ligament; *d*, the cavernous and spongy bodies of the penis divided near the root; +, the spongy body of the bulb, above which the membranous part of the urethra, the prostate, &c.; *e*, the left os pubis close to the symphysis; *f*, the anus; *g*, the spine of the ischium, with the short sacro-sciatic ligament; *h*, auricular sacro-iliac surface; *i*, interior of the urinary bladder; *k*, exterior of the rectum; *l*, transverse process of the fourth lumbar vertebra; 1, lower part of the vena cava inferior; 1′, abdominal aorta; 2, common iliac veins; 2′, right common iliac artery; 3, external iliac veins; 3′, external iliac artery; 4, internal iliac veins, that of the right side entire, that of the left divided and in great part removed; 5, middle and other veins of the sacral plexus; 6, ilio-lumbar and lumbar veins; 7, right gluteal and upper lateral sacral veins; 8, 8′, obturator vein and artery of the right side; 9, pelvic plexus of veins of the right side; 9′, that of the left side connected with the lower vesical plexus; 10, placed on the right side on the short sacro-sciatic ligament immediately below the division of the internal iliac vein into the pudic and sciatic veins: on the left side, below 4, the sciatic vein is cut short; 10, lower down, the pudic vein; 10′, the perineal veins; 11, placed on the prostate among the lower vesical veins, into one of which the left dorsal vein of the penis, 11, is seen to pass; 12, placed on the lower part of the rectum, may indicate the plexus of hemorrhoidal veins.

The *vesical plexus* presents vessels over the whole of the bladder external

to its muscular coat, but they are particularly rich towards the base of the organ, and are there closely connected with the prostatic and hæmorrhoidal plexuses in the male, and with the vaginal plexus in the female.

The *prostatic plexus* receives two large vessels, one at each side, the divisions of the dorsal vein of the penis. These, coursing downwards and backwards on the sides of the prostate gland, expand into a close network at the base of the gland, which is quite encircled by it.

The *hæmorrhoidal plexus* consists of enlarged and copiously anastomosing veins in the walls of the lower part of tho rectum, immediately underneath the mucous membrane. From it proceed superior, middle, and inferior hæmorrhoidal veins accompanying the arteries of the same name, and it communicates freely with the plexuses in front of it. The superior hæmorrhoidal vein being a branch belonging to the portal system, the hæmorrhoidal plexus forms a very direct communication beween the portal and general venous systems.

The *vaginal plexus* surrounding the vagina, principally in its lower part, communicates freely with the hæmorrhoidal and vesical plexuses.

The *uterine plexus* pours its blood in greatest part into the ovarian veins, and is not considerable except in pregnancy.

The *dorsal* vein of the *penis* commences by branches which issue from the glans penis, and form in the first instance two veins, one at each side of the middle line, in the dorsal groove of the penis. These receive branches from the spongy body of the penis, and some superficial veins which accompany the external pudic arteries, and proceeding backwards unite and form a short trunk which enters the pelvis beneath the subpubic ligament. Hero it divides into two branches, which are directed obliquely downwards over the prostate and the neck of the bladder, and are united with the prostatic plexus.

COMMON ILIAC VEIN.

The common iliac vein is formed by the confluence of the external and internal iliac veins. Extending from the sacro-iliac articulation upwards to near the junction of the fifth with the fourth lumbar vertebra, at a point a little to the right of tho middle line, the two common iliac veins unite to form the lower or ascending vena cava. The right vein is shorter than the left, and is nearly vertical in its direction. The right vein is placed behind, and then to the outer side of its artery; whilst the left vein is to the inner side of the left common iliac artery, and then passes behind the right. These veins are destitute of valves.

PORTAL SYSTEM OF VEINS.

The portal vein differs from other veins of the body in being subdivided into branches at both its extremities. The branches of origin, by the union of which it may be said to be formed, are the veins of the chylo-poietic viscera, viz., the stomach, intestine, pancreas, and spleen; the other branches, or those of distribution, ramifying after the manner of an artery in the substance of the liver, convey to the capillaries of that organ the blood collected in the main trunk. This blood, together with that of the hepatic artery, after having served for the secretion of the bile and the nourishment of the liver, is withdrawn from that organ by the hepatic veins, and carried by them into the vena cava inferior.

THE PORTAL VEIN OR VENA PORTÆ is about three inches in length. Commencing at the junction of the splenic and superior mesenteric veins, it

passes upwards and a little to the right to reach the transverse fissure of the liver. It is placed close behind the hepatic artery and the bile duct: and

Fig. 326.

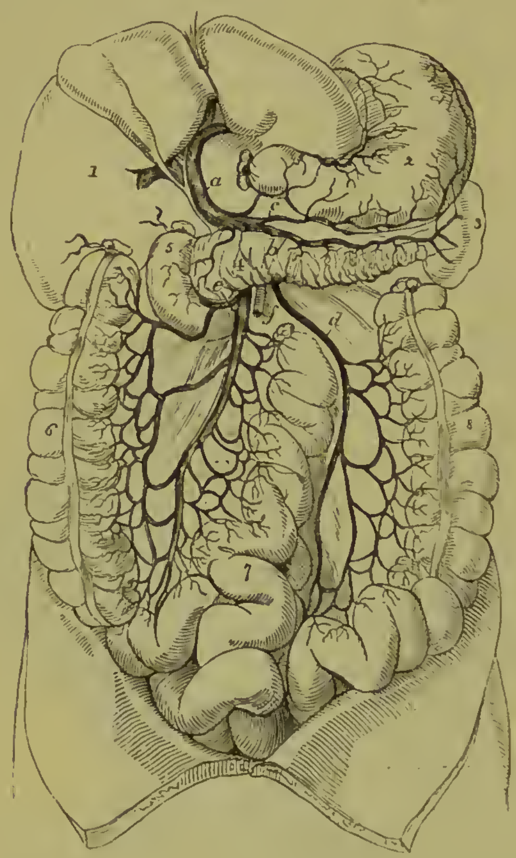


Fig. 326.—View of the Principal Branches of the Vena Portæ. $\frac{1}{6}$

1, lower surface of the right lobe of the liver; 2, stomach; 3, spleen; 4, pancreas; 5, duodenum; 6, ascending colon; 7, small intestines; 8, descending colon; *a*, vena portæ dividing in the transverse fissure of the liver; *b*, splenic vein; *c*, right gastro-epiploic; *d*, inferior mesenteric; *e*, superior mesenteric vein; *f*, superior mesenteric artery.

is surrounded by the filaments of the hepatic plexus of nerves, together with numerous lymphatics. All these are imbedded in loose connective tissue, and enclosed within the layers of the small omentum. Within the transverse fissure it is somewhat enlarged, and is there named *sinus of the portal vein.*

Near the right end of the transverse fissure, the vena portæ divides into two branches. That of the *right* side enters directly the substance of the corresponding lobe of the liver, and spreads out into branches, each of which is accompanied by an offset of the hepatic artery and of the hepatic duct. The *left* branch, which is smaller, but necessarily longer, passes across to gain the left end of the transverse fissure, where it enters the liver and ramifies like the preceding branch.

Tributaries.—The principal branches which by their union contribute to form the vena portæ are the coronary vein of the stomach, the superior mesenteric and the splenic veins. The cystic vein is also sometimes a lateral tributary of the portal vein, but more frequently proceeds from its right branch.

The *coronary* vein of the stomach lies parallel with the artery of the same name. Its size is inconsiderable, and its direction transverse from the cardiac to the pyloric end of the stomach along the small curvature. On reaching the latter point it turns downwards, and opens into the trunk of the vena portæ.

The splenic vein, a vessel of very considerable size, returns the blood not only from the spleen, but also from the pancreas, the duodenum, the greater part of the stomach and omentum, the descending colon, and part of the rectum. It commences by five or six branches, which issue sepa-

rately from the fissure of the spleen, and soon join to form a single vessel. It is directed from left to right beneath the pancreas, in company with the splenic artery, below which it is placed. On reaching the front of the spine it joins the superior mesenteric vein, nearly at a right angle. It receives

Fig. 327.

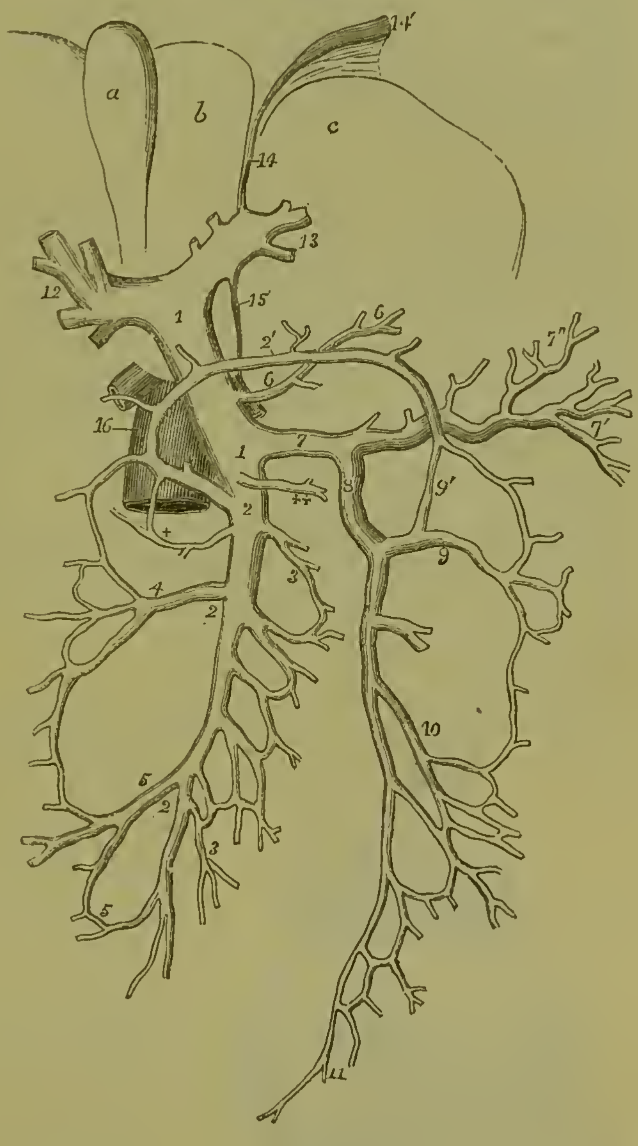


Fig. 327.—Diagrammatic Outline of the Portal Vein and its relation to the Liver, &c. $\frac{1}{4}$

The liver is supposed to be turned upwards so as to present a portion of its under surface. *a*, gall-bladder; *b*, square lobe; *c*, left lobe; 1, trunk of the vena portæ; 2, great or superior mesenteric vein; 2′, its middle colic branch, forming loops of communication between the right and left colic veins; 3, intestinal branches; +, small pancreatico-duodenal branch; 4, right colic branch; 5, ileo-colic; 6, coronary vein of the stomach; + +, right gastro-epiploic; 7, splenic vein; 7′, its branches to the spleen; 7″, its branches to the stomach; 8, inferior mesenteric vein; 9, left colic branch; 9′, its communication with the middle colic; 10, sigmoid; 11, hemorrhoidal; 12, the right, and 13, the left division of the vena portæ in the transverse fissure of the liver; 14, the obliterated cord of the umbilical vein passing through the antero-posterior fissure to join the left division of the vena portæ; 15, the obliterated cord of the ductus venosus passing from the left division of the vena portæ to one of the hepatic veins connected with 16, the vena cava inferior, of which a part is represented in shade.

gastric branches (vasa brevia) from the left extremity of the stomach, the *left gastro-epiploic* vein, some *pancreatic* and *duodenal* branches, and also the inferior mesenteric vein.

Mesenteric Veins.—The *superior mesenteric* vein lies to the right side, and somewhat in front of the artery of the same name. The distribution of its branches corresponds with that of the superior mesenteric artery, and it returns the blood from the several parts supplied by that vessel, viz., from the small intestine, and from the ascending and transverse parts of the

colon. The trunk, formed by the union of its several branches, inclines upwards and to the right side, passing in front of the duodenum and behind the pancreas, where it joins with the splenic vein to form the venæ portæ.

The branches of the *inferior mesenteric* vein correspond with the ramifications of the artery of the same name. They commence at the lower part of the rectum in the hæmorrhoidal plexus, and unite into a single vessel near the sigmoid flexure of the colon. From this point the vein proceeds upwards and inwards along the lumbar region, behind the peritoneum, crossing between the transverse mesocolon and the spine, or farther to the left, and then passing beneath and behind the pancreas, it reaches the splenic vein in which it terminates.

VEINS OF THE HEART.

The greater number of the *cardiac veins* are collected into a large common trunk which pours its blood into the posterior part of the right auricle, in the angle between the inferior vena cava and the right auriculo-ventricular orifice. The terminal part of this vein is considerably dilated, and is named the *coronary sinus.* The principal veins leading into it are named the *great*, the *posterior*, and the *anterior* or small coronary veins. Among these the first alone deserves the name of coronary, as it surrounds the heart in the left auriculo-ventricular groove.

Besides the larger cardiac veins which join the great coronary sinus, there are also small separate veins (venæ minimæ cordis), which open directly into the right auricle, especially along its right border. The openings of these veins, as well as some depressions which do not admit veins, have been named *foramina Thebesii.*

Fig. 328.

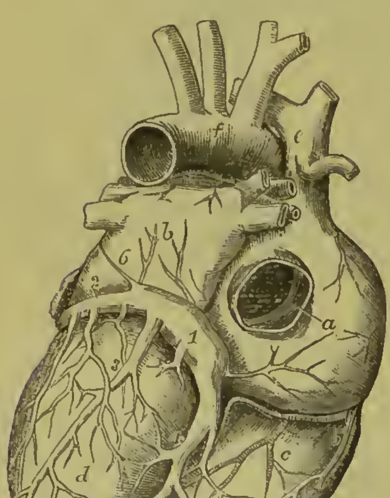


Fig. 328.—View of the Adult Heart, from behind, to show the Coronary Veins. $\frac{1}{3}$

a, placed on the back of the right auricle, points to the Eustachian valve seen within the opening of the inferior vena cava ; *b*, the back of the left auricle ; *c*, back of the right ventricle ; *d*, left ventricle ; *e*, vena cava superior ; *f*, arch of the aorta ; 1, sinus of the great coronary vein ; 2, great coronary vein turning round the heart in the auriculo-ventricular groove ; 3, 4, posterior branches ; 5, one of the small right cardiac veins passing directly into the right auricle ; 6, the vestige of the left superior vena cava proceeding over the left auricle downwards to join the coronary sinus.

The veins of the heart are without valves excepting at their terminations.

The *great cardiac* vein (vena cordis magna) is a vessel of considerable size, and from the way in which it coils round the left side of the base of the heart, or rather of the ventricle, it may be named "coronary." Its chief branch runs along the groove upon the fore part of the heart, corresponding with the septum of the ventricles. Commencing at the apex of the heart, it gradually increases in size as it approaches the base of the ventricles, and then inclining backwards and to the left side in the groove between the left

auricle and ventricle, ends in the coronary sinus : a valve of two segments closes its aperture in the sinus. In this course it receives branches from the ventricles, especially from the left, and also from the left auricle ; and as it passes round the thick margin of the left ventricle, it receives a vein of some size, which ascends to join it.

The *posterior cardiac* veins ascend on the back of the ventricles, especially on the left, and open into the coronary sinus by four or more valved orifices. One of these, larger than the rest (middle or posterior cardiac vein), ascends along the groove between the ventricles upon the posterior surface of the heart. It commences by small branches at the apex of the heart, which communicate with those of the preceding vein, and then ascends to the base, receiving branches from the substance of both ventricles.

The *small* or *anterior cardiac* veins (venæ cordis parvæ) are several small branches, which commence upon the anterior surface of the right ventricle, and passing upwards and outwards, open separately into the right auricle, after having crossed over the groove between it and the ventricle.

The *coronary sinus* is about an inch in length, and is placed at the back of the heart in the transverse groove between the left auricle and ventricle, where it is covered by the muscular fibres of the auricle. At one end it is joined by a small vein from the right side, and opens into the right auricle beneath the Thebesian valve ; at the other, it receives the large coronary vein, and a small straight vein directed obliquely along the back of the left auricle ; whilst between those points other veins enter it from the back of the heart. All the veins joining it, except the small oblique vein, are provided with more or less complete valves at their terminations.

The coronary sinus, together with the small oblique vein above referred to, considered with reference to their early fœtal condition and certain malformations to which they are subject along with other neighbouring veins, may be looked upon rather as the persistent terminal parts of a typically distinct left superior vena cava, than as simply the main stem of the cardiac veins. The explanation of this will be found in what follows on the development of these veins.

DEVELOPMENT OF THE GREAT VEINS.

In the young fœtus before the development of the allantois, a right and a left omphalo-mesenteric vein bring back the blood from the walls of the umbilical vesicle, and unite to form a short trunk, which is continued into the auricular extremity of the rudimentary heart.

In the first commencement of the placental circulation, or in the third week of fœtal life (Coste), two umbilical veins have been seen coming from the placenta, and uniting to form a short trunk, which opens into the common omphalo-mesenteric vein. Very soon the right omphalo-mesenteric vein and right umbilical vein disappear. In connection with the common trunk of the umbilical and omphalo-mesenteric veins two sets of vessels make their appearance in the young liver. Those furthest from the heart, named *venæ hepaticæ advehentes*, become the right and left divisions of the portal vein ; the others are the hepatic veins, *venæ hepaticæ revehentes*. The portion of vessel intervening between those two sets of veins forms the *ductus venosus* (p. 329), and the part above the hepatic vein, being subsequently joined by the ascending vena cava, forms the upper extremity of that vein. Into the remaining or left omphalo-mesenteric vein open the mesenteric and splenic veins. The part above the latter forms the trunk of the portal vein ; and the portion of vessel between the union of this with the umbilical vein and the origin of the venæ hepaticæ advehentes is so altered that the portal trunk opens into the commencement of the right vena advehens.

At the time of the commencement of the placental circulation, two short transverse venous trunks, the *ducts of Cuvier*, open, one on each side, into the auricle of

the heart. Each is formed by the union of a superior and an inferior vein, named the primitive jugular and the cardinal.

The *primitive jugular* vein receives the blood from the cranial cavity by channels in front of the ear, which are subsequently obliterated; in the greater part of its extent it becomes the external jugular vein; and near its lower end it receives small branches, which grow to be the internal jugular and subclavian veins. The *cardinal veins* are the primitive vessels which return the blood from the Wolffian bodies, the vertebral column, and the parietes of the trunk. The inferior vena cava is a vessel of later development, which opens into the trunk of the umbilical and omphalo-mesenteric veins, above the venæ hepaticæ revehentes. The iliac veins, which unite to form the inferior vena cava, communicate with the cardinal veins. The inferior extremities of the cardinal veins are persistent as the internal iliac veins. Above the iliac veins the

Fig. 329.

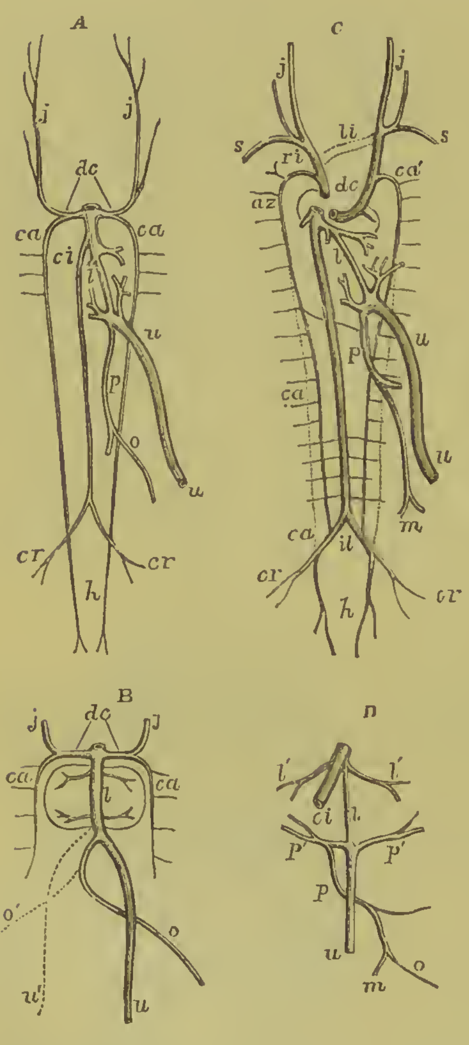


Fig. 329. — Diagrams illustrating the development of the Great Veins (after Kölliker).

A, plan of the principal veins of the fœtus of about four weeks, or soon after the first formation of the vessels of the liver and the vena cava inferior.

B, veins of the liver at a somewhat earlier period.

C, principal veins of the fœtus at the time of the first establishment of the placental circulation.

D, veins of the liver at the same period.

dc, the right and left ducts of Cuvier; *ca*, the right and left cardinal veins; *j, j*, the jugular veins; *s*, the subclavian veins; *az*, the azygos vein; *u*, the umbilical or left umbilical vein; *u'* in B, the temporary right umbilical vein; *o*, the omphalo-mesenteric vein; *o'*, the right omphalo-mesenteric vein; *m*, the mesenteric veins; *p*, the portal vein; *p'*, *p'*, the venæ advehentes; *l*, the ductus venosus; *l'*, *l'*, the hepatic veins; *ci*, vena cava inferior; *il*, the division of the vena cava inferior into common iliac veins; *cr*, the external iliac or crural veins; *h*, the hypogastric or internal iliac veins, in the line of continuation of the primitive cardinal veins.

In C, *li*, in dotted lines, the transverse branch of communication between the jugular veins which forms the left innominate vein; *ri*, the right innominate vein; *ca'*, the remains of the left cardinal vein by which the superior intercostal veins fall into the left innominate vein; above *p*, the obliquely crossing vein by which the hemiazygos joins the azygos vein.

cardinal veins are obliterated in a considerable part of their course; their upper portions then become continuous with two new vessels, the *posterior vertebral veins* of Rathke, which receive the lumbar and intercostal twigs.

As development proceeds, the direction of the ducts of Cuvier is altered by the descent of the heart from the cervical into the thoracic region, and becomes continuous with that of the primitive jugular veins. A communicating branch makes its appearance, directed transversely from the junction of the left subclavian and jugular veins, downwards, and across the middle line to the right jugular; and further down

in the dorsal region between the posterior vertebral veins a communicating branch passes obliquely across the middle line from right to left. The communicating branch between the primitive jugular veins forms the left innominate vein. The portion of vessel between the termination of the right subclavian vein and the termination of the communicating branch becomes the right innominate vein. The portion of the primitive jugular vein below the communicating vein, together with the right duct of Cuvier, forms the vena cava superior, while the cardinal vein opening into it is the extremity of the great vena azygos. On the left side, the portion of the primitive jugular vein placed below the communicating branch, and the cardinal and posterior vertebral veins, together with the cross branch between the two posterior vertebral veins are

Fig. 330.

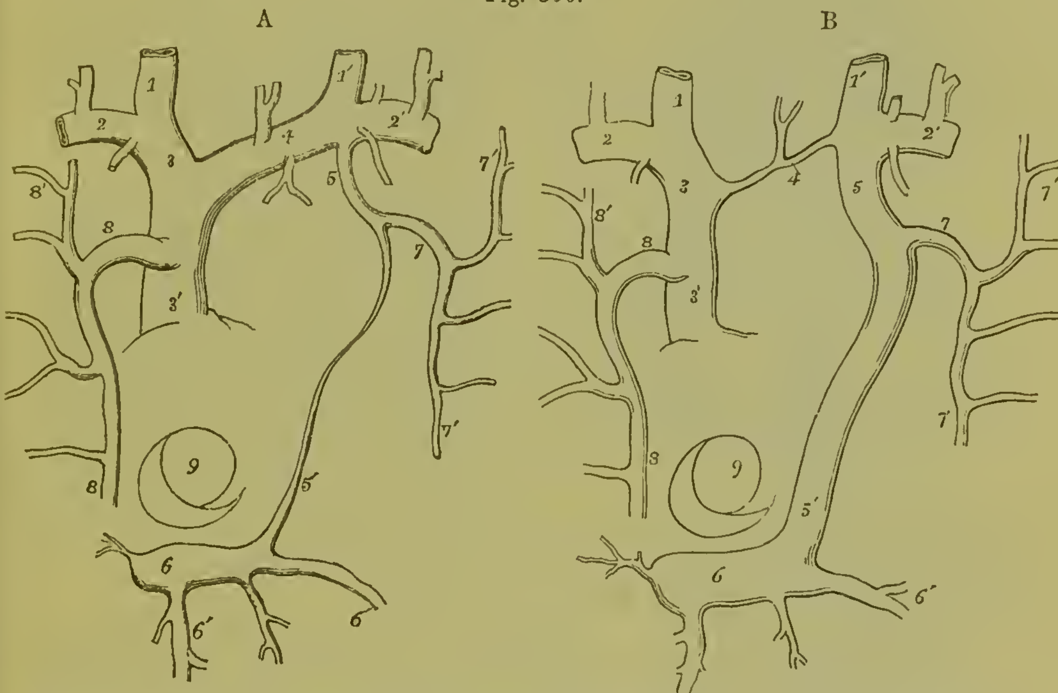


Fig. 330, A and B.—Diagrammatic Outlines of the Vestige of the Left Superior Cava and of a Case of its Persistence (sketched after Marshall). ⅓

A, Brachio-cephalic veins with the superior intercostal, azygos, and principal cardiac veins.

B, the same in a case of persistence of the left superior cava, showing its communication with the sinus of the coronary vein. The views are supposed to be from before, the parts of the heart being removed.

1, 1′, the internal jugular veins; 2, 2′, subclavian veins; 3, right innominate; 3′, right or regular superior cava; 4, in A, the left innominate; in B, the transverse or communicating vein between the right and left superior venæ cavæ; 5, in A, the opening of the superior intercostal vein into the innominate; 5′, vestige of the left superior cava or duct of Cuvier; 5, 5′, in B, the left vena cava superior abnormally persistent, along with a contracted condition of 4, the communicating vein; 6, the sinus of the coronary vein; 6′, branches of the coronary veins; 7, the superior intercostal trunk of the left side, or left cardinal vein; 8, the principal azygos or right cardinal vein; 7′, 8′, some of the upper intercostal veins; 9, the opening of the inferior vena cava, with the Eustachian valve.

converted into the left superior intercostal and left superior and inferior azygos veins. The variability in the adult arrangement of these vessels depends on the various extent to which the originally continuous vessels are developed or atrophied at one point or another. The left duct of Cuvier is obliterated, except at its lower end, which always remains pervious as the coronary sinus. Even in the adult, traces of the existence of this vessel can always be recognised in the form of a fibrous band, or sometimes even a narrow vein, which descends obliquely on the left auricle; and in front of the root of the left lung there remains a small fold of the serous membrane

of the pericardium, the *vestigial* fold of the pericardium, so named by Marshall, to whom is due the first full elucidation of the nature and relations of the left primitive vena cava.

The left duct of Cuvier has been observed persistent as a small vessel in the adult. More frequently a right and left innominate vein open separately into the right auricle, an arrangement which is also met with in birds and in certain mammalia, and which results from the vessels of the left side being developed similarly to those of the right, while the cross branch remains small or absent. (Quain on the Arteries, plate 58, figs. 9 and 10.)

Fig. 331.

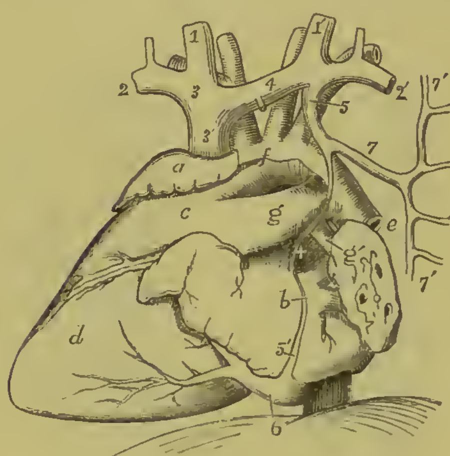


Fig. 331.—View of the Fœtal Heart and Great Vessels, from the left side, to show the Vestige of the Left Superior Cava Vein in situ. (This figure is planned after one of Marshall's, and slightly altered according to an original dissection.)

a, right auricle; *b*, left auricle and pulmonary veins; *c*, the conus arteriosus of the right ventricle; *d*, the left ventricle; *e*, descending aorta; +, vestigial fold of the pericardium; *f*, arch of the aorta, with a part of the pericardium remaining superiorly; *g*, main pulmonary artery and ductus arteriosus; *g′*, left pulmonary artery; 1, 1′, right and left internal jugular veins; 2, 2′, subclavian veins; 3, right innominate and superior vena cava; 4, left innominate or communicating vein; 5, 5′, remains of the left superior cava and duct of Cuvier, passing at + in the vestigial fold of the pericardium, joining the coronary sinus below, and receiving above the superior intercostal vein, 7; 7′, 7′, the upper and lower intercostal vein, joining into one.

A case is recorded by Gruber, in which the left vena azygos opened into the coronary sinus, and was met by a small vein descending from the union of the subclavian and jugular. (Reichert and Dubois Reymond's Archiv. 1864, p. 729.) In this case, the jugular veins had been developed in the usual manner, while the left vena azygos continued to pour its blood into the duct of Cuvier.

(Consult Kölliker, Entwicklungsgeschichte, p. 414, et seq.; J. Marshall, on the Development of the great Anterior Veins in Man and Mammalia, in Phil. Trans., part i., 1850; and Wenzel Gruber, Über die Sinus Communis und die Valvulæ der Venæ Cardiacæ, &c., in Mém. de l'Acad. impér. des Scien. de St. Petersbourg, 1864; and in Virchow's Archiv., Jan. 1865.)

THE ABSORBENTS.

The absorbent vessels are divisible physiologically into two sets;—the *lacteals*, which convey the chyle from the alimentary canal to the thoracic duct; and the *lymphatics*, which take up the lymph from all the other parts of the body, and return it into the venous system. Anatomically considered, however, the lacteals are not different from the lymphatics, and may be regarded as the absorbents of the mucous membrane of the intestine. The larger lacteals and lymphatics are provided with valves, which give them, when distended, a somewhat moniliform appearance; and both are connected in their course with *lacteal* or *lymphatic* glands.

The general anatomy of the absorbents having been elsewhere detailed, only their course and position remain to be here described. They are gathered into a right and a left trunk, which open into the angles of union of the subclavian and internal jugular veins. The large vessel of the left side traversing the thorax is named *the thoracic duct:* it receives not only the lymphatics of its own side of the head and arm, but likewise the lymphatics of both lower limbs, and the whole of the lacteals. The vessel of the right side is named the *right lymphatic duct,* and receives lymphatics only.

Fig. 332.

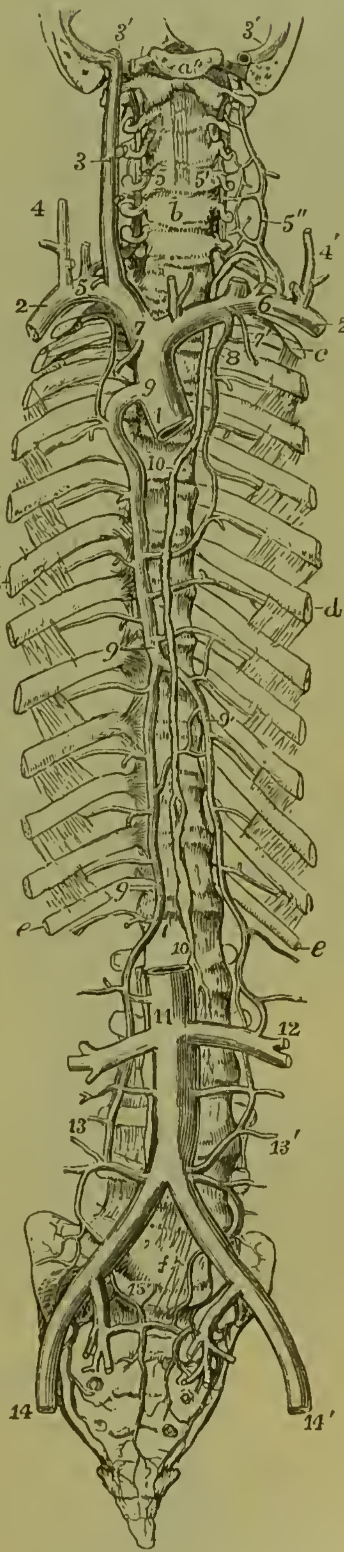


Fig. 332.—Sketch of the Thoracic Duct with the Principal Systemic Veins.

The full description of this figure will be found at page 454.

10, 10, indicate the thoracic duct; the lower number is close to the receptaculum chyli, the upper is on the fourth dorsal vertebra, above which the duct inclines to the left; 6, on the left subclavian vein, marks the termination of the duct in the angle of union of the subclavian and internal jugular veins; 5, on the right subclavian vein, indicates the similar termination of the right lymphatic trunk.

THORACIC DUCT.

The thoracic duct is the common trunk which receives the absorbents from both the lower limbs, from the abdominal viscera (except part of the upper surface of the liver), and from the walls of the abdomen, from the left side of the thorax, left lung, left side of the heart, and left upper limb, and from the left side of the head and neck. It is from fifteen to eighteen inches long in the adult, and extends usually from the second lumbar vertebra to the root of the neck. Its commencement, however, is often as low as the third lumbar vertebra; and in some cases as high as the first lumbar, or even upon the last dorsal vertebra. Here there is usually a dilatation of the duct, of variable size, which is called *receptaculum chyli* (Pecquet), and is the common point of junction of the lymphatics from the lower limb with the trunks of the lacteal vessels.

The lower part of the thoracic duct is generally wider than the rest, being about three lines in diameter; it lies at first to the right side of or behind the

aorta; it then ascends on the right side of that vessel, in contact with the right crus of the diaphragm, to the thorax, where it is placed at first upon the front of the dorsal vertebræ, between the aorta and the azygos vein. The duct ascends, gradually inclining to the left, and at the same time diminishing slightly in size, until it reaches the third dorsal vertebra, where, passing behind the arch of the aorta, it comes into contact with the œsophagus, lying between the left side of that tube and the pleura. Continuing its course into the neck to the level of the upper border of the seventh cervical vertebra, it changes its direction and turns forwards, at the same time arching downwards and outwards so as to describe a curve over the apex of the pleura, and then terminates on the outer side of the internal jugular vein, in the angle formed by the union of that vein with the subclavian. The diminution in the size of the duct as it ascends is such that at the fifth dorsal vertebra it is often only two lines in diameter, but above this point it again enlarges. The duct is generally waving and tortuous in its course, and is constricted at intervals so as to give it a varicose appearance.

The thoracic duct is not always a single trunk throughout its whole extent; it frequently divides opposite the seventh or eighth dorsal vertebra into two trunks, which soon join again; sometimes it separates for a short distance into three divisions, which afterwards unite, and enclose between them spaces or islets. Cruikshank in one case found the duct double in its entire length; "in another triple, or nearly so." In the neck, the thoracic duct often divides into two or three branches, which in some instances terminate separately in the great veins, but in other cases unite first into a common trunk. In a case of right aortic arch the thoracic duct has been observed to end in the veins of the right side (A. Thomson).

The thoracic duct has numerous double valves at intervals throughout its whole course, which are placed opposite to the nodulated parts of the vessel. They are more numerous in the upper part of the duct. At the termination of the duct in the veins there is a valve of two segments, so placed as to allow the contents of the duct freely to pass into the veins, but which would effectually prevent the reflux of either chyle or blood into the duct.

THE RIGHT LYMPHATIC DUCT.

The right lymphatic duct is a short vessel, about a line or a little more in diameter, and about a quarter or half an inch in length, which receives the lymph from the absorbents of the right upper limb, the right side of the head and neck, the right side of the chest, the right lung, and the right half of the heart, and from part of the upper surface of the liver. It enters obliquely into the receding angle formed by the union of the right subclavian and internal jugular veins, where its orifice is guarded by a double valve.

LYMPHATICS OF THE LOWER LIMB

AND SURFACE OF THE LOWER HALF OF THE TRUNK.

The lymphatics of the lower limb are arranged in a superficial and a deep series. Those of the superficial series, together with the superficial lymphatics of the lower half of the trunk, converge to the superficial inguinal glands; with the exception of a few which dip into the popliteal space. Those of the deep series converge to the deep inguinal glands.

The *popliteal lymphatic glands*, usually very small, and four or five in number, surround the popliteal vessels, and are imbedded in a quantity of loose fat. They receive from below the deep lymphatics of the leg, and those which accompany the short saphenous vein ; and from them proceed efferent vessels, which ascend with the femoral artery to the groin.

Fig. 333.

Fig. 333.—View of the Superficial Lymphatic Vessels and Glands of the Right Groin and Lower Limb, as seen from the Front and Inner Side (founded on Mascagni and others). $\frac{1}{6}$

1, 1, upper inguinal glands receiving the lower abdominal, the inguinal, penal, and scrotal lymphatic vessels; 2, 2, femoral or lower inguinal glands receiving the anterior internal and external femoral lymphatic vessels ; 2′, the internal lymphatic vessels ; 3, 3, large plexus of lymphatic vessels in the course of the saphenous veins ; 4, the same descending upon the leg ; 5, posterior lymphatics of the calf of the leg ; 6, lymphatic vessels of the dorsum of the foot ; 7, those of the heel and inner ankle.

The *superficial inguinal glands* vary much in number, amounting on an average to eight or ten : they are divisible into a superior or oblique and an inferior or vertical set. The oblique glands lie in the line of Poupart's ligament and receive lymphatics from the integuments of the trunk and genital organs, together with a few from the upper and outer part of the limb : the vertical glands surround the upper part of the long saphenous vein, and extend two or three inches downwards along the course of that vessel ; they receive the greater number of the lymphatics which ascend from the limb. The efferent vessels of the superficial inguinal glands perforate the fascia, come into connection with those situated deeply, pass into the abdomen by the side of the blood-vessels, and terminate in a chain of lymphatics which lie along the external iliac artery, and end in the lumbar glands.

The *deep-seated inguinal glands* are placed beneath the others, and surround the femoral artery and vein.

The *superficial lymphatics of the lower limb* arise in two sets, one from the inner part of the dorsum and sole of the foot, the other from the outer. The *inner* vessels follow a similar course to that of the internal saphenous vein: passing partly in front and partly behind the inner ankle, they ascend along the inner side of the knee and front of the thigh, and terminate in the superficial inguinal glands. The *outer* vessels, ascending from the outer side of the foot, pass in great part obliquely across the popliteal space to join tho inner set above the knee; in part they reach the inner set by crossing in front of the tibia; and a small number of them accompanying the external saphenous vein, dip down between the heads of the gastrocnemius muscle, and end in the popliteal glands. From the middle line of the back of the thigh lymphatics pass round on both sides to reach the inguinal glands. (Mascagni, Vasorum Lymph. Historia, 1787.)

The *deep-seated lymphatics of the lower limb* are associated in their whole course with the deep blood-vessels. In the leg they consist of three divisions, namely, anterior tibial, posterior tibial, and peroneal. Neither these nor the superficial absorbents pass through any lymphatic gland in the leg, unless it be those lymphatics which accompany the anterior tibial artery, near which a small gland is sometimes found on the front of the inter-osseous ligament, above the middle of the leg. Tho several sets of deep lymphatics in the leg enter the lymphatic glands situated in the popliteal space. The efferent vessels from those glands are joined by others in contact with the branches of the femoral artery, and enter the deep inguinal glands. Other deep lymphatics, derived from the muscles of the gluteal region, and many proceeding from the adductor muscles of the thigh, enter the cavity of the pelvis in company with the gluteal, sciatic, and obturator arteries, and pass through a series of glands situated in the neighbourhood of the internal and common iliac arteries.

The *superficial lymphatics of the lower half of the trunk* converge to the superficial inguinal glands, the direction of some of them being indicated by the superficial circumflex iliac and epigastric, and the external pudic arteries. Externally they converge to the groin from the gluteal region and from the lower part of the back, those from the back crossing others which pass upwards to the axillary glands. Anteriorly they descend from the greater part of the surface of the abdomen, crossing and mingling above the umbilicus with vessels which ascend towards the axillary glands.

The *superficial lymphatics of the penis* usually form three vessels, two being placed at the sides, and the other on the dorsum of the organ. Commencing in the prepuce and beneath the mucous lining of the urethra, they pass backwards, unite on the dorsum penis, and, again subdividing, send branches on each side to the oblique inguinal glands. The *deep-seated* lymphatics of the penis pass under the pubic arch, and end in the glands on the internal iliac artery.

The *lymphatics of the scrotum* pass to the superficial inguinal glands along the course of the external pudic arteries.

The lymphatics of the external generative organs in the female present a disposition similar to that existing in the male.

ABSORBENTS OF THE ABDOMEN AND PELVIS.

The *external iliac lymphatic glands*, from six to ten or more in number, clustering round the external iliac artery, receive the efferent vessels from both deep and superficial inguinal glands.

The *internal iliac lymphatic glands*, a numerous series placed on the internal iliac artery, and the *sacral glands*, placed in the hollow of the sacrum, receive the lymphatics from the pelvic viscera and parietes.

The *lumbar lymphatic glands* are very large and numerous; they are placed in front of the lumbar vertebræ, around the aorta and vena cava. To these proceed the efferent vessels of the glands already mentioned, as well as those which accompany several of the branches of the abdominal aorta.

The efferent absorbent vessels which proceed from the lumbar glands progressively increase in size, while their number diminishes, and at length they unite into a few trunks, which, with those of the lacteals, form the origin of the thoracic duct.

The *deep lymphatics of the abdominal wall* in part pass along the circumflex iliac and epigastric arteries to the external iliac glands; the greater number are directed backwards with the ilio-lumbar and lumbar arteries, and, being joined by the lymphatics from the muscles of the back, pass behind the psoas muscle to the vertebral column, where they enter the lumbar glands.

The *lacteals* (vasa lactea, chylifera) commence in the coats of the intestines, by a very close plexus, and extend to the thoracic duct, in which they all terminate: they are derived in far larger numbers from the small than from the large intestine, so that they abound in the mesentery, and particularly in that of the jejunum and ileum. Two series of absorbent vessels are found along the tube of the intestine, having different positions and directions: those nearest to the outer surface of the intestine run longitudinally in the course of the canal, lying beneath the peritoneal coat; whilst others, placed more deeply between the muscular and mucous coats, run transversely round the intestine, and are directed thence with the arteries and veins along the mesentery, enclosed between the two layers of the peritoneum. (Cruikshank, Anatomy of the Absorbent Vessels, p. 162.) Sometimes the more superficial absorbents of the intestine are named lymphatics, to distinguish them from the deep set which are those which absorb the chyle from the cavity of the intestine. According to Teichmann (Das Saugader-system, 1861, p. 75), the two plexuses have no capillary anastomoses, but communicate only through valved vessels: this they do freely. The lacteals, having entered the mesentery, take the course of the blood-vessels, and pass through numerous lymphatic glands (mesenteric glands).

The *mesenteric glands* vary in number from a hundred and thirty to a hundred and fifty; and in the healthy state are seldom larger than an almond. They are most numerous in that part of the mesentery which corresponds with the jejunum; and they seldom occur nearer to the attached border of the intestine than two inches. In mesenteric disease they are subject to enlargement, and become the seat of unhealthy deposits. Small glands in limited numbers are also disseminated irregularly between the folds of the peritoneum connected with the large intestines.

Having passed through these glands, the lacteals gradually unite as they approach the attached border of the mesentery, and so become diminished in number but increased in size, until at length, near the root of the superior mesenteric artery, only two or three trunks remain, which end in the thoracic duct. Sometimes, however, six or seven of these vessels open separately into the commencement of the duct. Those from the descending colon and its sigmoid flexure usually join some of the lumbar lymphatics, or

Fig. 334.

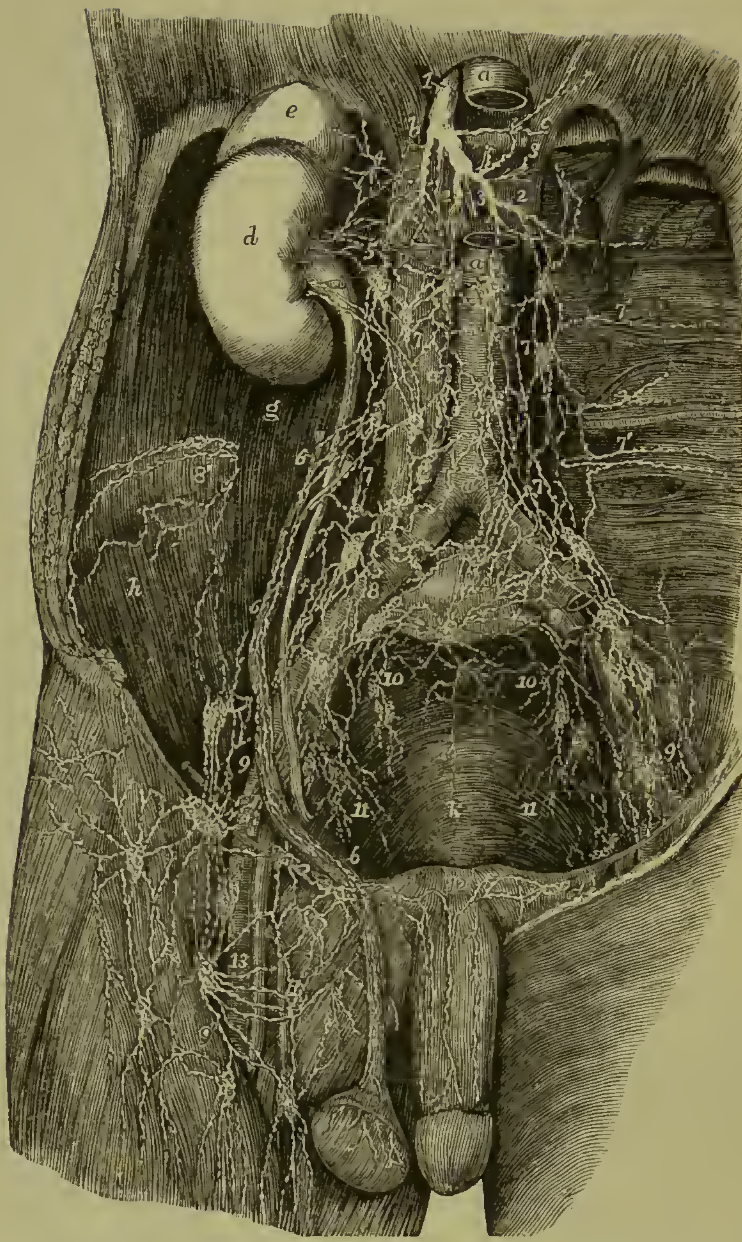


Fig. 334.—Principal Lymphatic Vessels and Glands of the Abdomen and Pelvis (modified from Mascagni). $\frac{1}{4}$

a, the abdominal aorta, the upper part of it having been removed to show the deepest lumbar plexuses of lymphatics ; *a'*, the vena cava inferior ; *b*, the right, *c*, the left crus of the diaphragm ; *d*, the right kidney ; *e*, the suprarenal body ; *f*, the ureter ; *g*, the psoas muscle ; *h*, the iliacus ; *k*, the lower part of the sacrum within the pelvis ; 1, the commencement of the thoracic duct ; 2, 3, 2, the largest of the lymphatic and lacteal trunks which join the thoracic duct, the hepatic, splenic, gastric, &c. ; 4, the suprarenal lymphatics ; 5, the renal, joining some of the lumbar plexus ; 6, the spermatic ; 7, 7, the lumbar lymphatic vessels and glands ; 7', 7', some of the lymphatics of the loins ; 8, 8, those surrounding the common iliac vessels, and proceeding from the lymphatics of the pelvis and lower limb ; 9, 9, the external iliac ; 10, 10, the internal iliac receiving those from the sacrum, walls of the pelvis, and at 11, 11, and at *k*, those from the viscera (bladder and rectum) ; 12, lymphatics of the dorsum of the penis passing to those of the groin ; 13, the deep femoral lymphatics and glands.

turn upwards and open by a separate trunk into the lower end of the thoracic duct.

The *absorbents of the stomach*, like those of the intestines, are placed, some beneath the peritoneal coat, and others between the muscular and mucous coats. Following the direction of the blood-vessels, they become arranged into three sets. Those of one set accompany the coronary vessels, and receiving, as they run from left to right, branches from both surfaces of the organ, turn backwards near the pylorus, to join some of the larger trunks. Another series, from the left end of the stomach, follow the vasa brevia, and unite with the lymphatics of the spleen : whilst those of the third set, guided by the right gastro-epiploic vessels, incline from left to right along the great curvature of the stomach, from which they pass backwards, and at the root of the mesentery terminate in one of the principal efferent *lacteal* vessels.

The *absorbents of the rectum*, likewise in two strata, are frequently of considerable size : immediately after leaving the intestine, some of them pass through small glands which lie contiguous to it ; finally, they enter the lymphatic glands situated in the hollow of the sacrum, or those higher up in the loins. At the anus their capillary network is continuous with that of the cutaneous absorbents.

The *lymphatics of the spleen* are placed, some immediately under its peritoneal covering, others in the substance of the organ. Both sets converge to the inner side of the spleen, come in contact with the blood-vessels, and, accompanying these, pass through a series of small glands, and terminate in the larger lymphatics of the digestive organs.

Lymphatics emerge from the *pancreas* at different points, and join those derived from the spleen.

The *lymphatics of the liver* are divisible into three principal sets, according as they are placed upon its upper or its under surface, or are spread through its substance with the blood-vessels.

The lymphatic vessels on the *upper surface of the liver* incline towards particular points, and so become distinguishable into groups, of which four are usually enumerated. 1. From the middle of this surface five or six branches run towards the falciform ligament, and being directed forwards on this membrane, they unite to form a large trunk, which passes upwards between two slips of the attachment of the diaphragm, behind the ensiform cartilage. Having reached the interpleural space behind the sternum, they ascend through a chain of lymphatic glands found upon the internal mammary blood-vessels. 2. The second group consists of vessels which incline outwards towards the right lateral ligament, opposite to which they unite into one or two larger lymphatics ; these pierce the diaphragm, and run forwards upon its upper surface to join the preceding set of vessels behind the sternum. In some cases, however, instead of passing into the thorax, they turn inwards on reaching the back part of the liver, and, running upon the crus of the diaphragm, open into the thoracic duct close to its commencement. 3. Another set of lymphatics is found upon the left lobe of the liver ; the vessels of which it is composed, after reaching the left lateral ligament pierce the diaphragm, and, turning forwards, end in the anterior glands of the mediastinum. 4. Finally, along the fore part of the liver some vessels will be observed to turn downwards and join those placed upon the under surface.

The *under* surface of the liver is covered by an open network of lymphatic vessels. On the right lobe they are directed over and under the gall-bladder to the transverse fissure, where some join the deep lymphatics ;

Fig. 335.

Fig. 335.—Diagrammatic Outline of the Principal Absorbent Vessels and Ducts. $\frac{1}{4}$

a, junction of the right jugular and subclavian veins in the right innominate; *b*, the same on the left side; 1, the thoracic duct, showing a division in its upper part; farther down a separation into two vessels enclosing a space between them, and at its lower extremity, 1′, the receptaculum chyli; 2, the principal cervical lymphatic vessels with the larger glands near their terminations; 3, 3′, the principal axillary lymphatic vessels and glands, joined by those from the shoulder and lower part of the neck; 4, 4′, the right and left internal mammary and anterior mediastinal lymphatic vessels (represented as more widely separated than natural); on the right side, 4′ and 4″, mark the junction with the internal mammary of the superior hepatic and anterior superior phrenic lymphatics; 5, some deeper mediastinal and pericardiac lymphatics; 6, 6′, deep mediastinal lymphatics passing into the right lymphatic trunk and thoracic duct; 7, the bronchial and pulmonary; 8, œsophageal; 9, posterior diaphragmatic lymphatics; 10, the intercostal and neighbouring lymphatics of the posterior thoracic wall represented chiefly on the left side; at 10′, is shown a small collateral trunk formed by the union of a number of the intercostal lymphatics; 11, 11, short trunks leading into the lower part of the thoracic duct, which receive some of the principal lymphatic vessels from the spleen, stomach, and pancreas, and the lacteal vessels from the intestines; 12, 12′, several main vessels, which collect the principal lymphatic vessels of the right and left lumbar plexus, and carry their contents into the thoracic duct; 13, 13′, right and left renal lymphatics; 14, 14′, right and left spermatic lymphatics; 15, aortic plexus, which farther down is continuous with the sacral; 16, 16′, right and left lumbar plexus, which receive the principal lymphatics of the pelvis and lower limbs.

whilst others, passing through some scattered lymphatic glands, are guided by the hepatic artery to the right side of the aorta, where they terminate in the thoracic duct. Branches also proceed to the concave border of the stomach, between the folds of the small omentum, to join with the coronary lymphatics of that organ.

The *deep lymphatics of the liver* accompany the branches of the portal vein in the substance of the organ, and pass out of the gland by the transverse fissure. After communicating with the superficial lymphatics, and also with those of the stomach, they pass backwards, and join, at the side of the cœliac artery, with one of the large *lacteal* trunks previously to its termination in the thoracic duct.

The *lymphatics of the kidney* likewise consist of a deep and a superficial set. Those placed upon the surface of the organ are comparatively small; they unite at the hilus of the kidney with other lymphatics from the substance of the gland, and then pass inwards to the lumbar lymphatic glands. The lymphatics of the *suprarenal capsules* unite with those of the kidney. The lymphatic vessels of the *ureter* are numerous; they communicate with those of the kidney and bladder, and for the most part terminate by union with the former.

The *lymphatics of the bladder*, taking rise from the entire surface of that organ, enter the glands placed near the internal iliac artery; with these are associated the lymphatics of the prostate gland and vesiculæ seminales.

The *lymphatics of the uterus*, in the unimpregnated state of the organ, are small, but during the period of gestation they are greatly enlarged. Issuing from the entire substance of the uterus, the greater number descend, together with those of the vagina, and pass backwards to enter the glands upon the internal iliac artery; thus following the course of the principal uterine blood-vessels. Others, proceeding from the upper end of the uterus, run outwards in the folds of peritoneum which constitute the broad ligaments, and join the lymphatics derived from the ovaries and Fallopian tubes. The conjoined vessels then ascend with the ovarian arteries, near the origin of which they terminate in the lymphatic vessels and glands placed on the aorta and vena cava.

The *lymphatics of the testicle* commence in the substance of the gland, and upon the surface of the tunica vaginalis. Collected into several large trunks, they ascend with the other constituents of the spermatic cord, pass through the inguinal canal, and accompany the spermatic vessels in the abdomen to enter some of the lumbar lymphatic glands.

LYMPHATICS OF THE THORAX.

The *lymphatic glands of the thorax.*—Along the course of the internal mammary blood-vessels there are placed six or seven small glands, through which pass the lymphatics situated behind the sternum; they may be named the *anterior mediastinal* glands. Between the intercostal muscles and in the line of the heads of the ribs on the side of the spine is a set of glands, named *intercostal*, which receive the lymphatics from the thoracic parietes and the pleura; their efferent ducts communicate freely with each other and open into the thoracic duct. Three or four *cardiac* lymphatic glands lie behind the aortic arch, and one before it: and another cluster, varying from fifteen to twenty in number, is found along the œsophagus, constituting the *œsophageal glands*. The *bronchial glands*, ten or twelve in number, are of much larger size than those just mentioned. The largest of

them occupy the interval between the right and left bronchi at their divergence, whilst others of smaller size rest upon the first divisions of these tubes

Fig. 336.

Fig. 336.—Lymphatic Vessels of the Head and Neck and of the Upper Part of the Trunk (from Mascagni). $\frac{1}{6}$

The chest and pericardium have been opened on the left side, and the left mamma detached and thrown outwards over the left arm, so as to expose a great part of its deep surface.

The principal lymphatic vessels and glands are shown on the side of the head and face, and in the neck, axilla, and mediastinum. Between the left internal jugular vein and the common carotid artery, the upper ascending part of the thoracic duct marked 1, and above this, and descending to 2, the arch and last part of the duct. The termination of the upper lymphatics of the diaphragm in the mediastinal glands, as well as the cardiac and the deep mammary lymphatics, are also shown.

for a short distance within the lungs. In early infancy their colour is pale red; towards puberty, we find them verging to grey, and studded with dark spots; at a more advanced age they are frequently very dark or almost black. In chronic diseases of the lungs they sometimes become enlarged and indurated, so as to press on the air-tubes and cause much irritation. They are frequently the seat of tuberculous deposits.

The *deep lymphatics of the thoracic walls* are divisible into two sets, the sternal and the intercostal. The *sternal* lymphatics, commencing in the muscles of the abdomen, ascend between the fibres of the diaphragm at its attachment to the ensiform cartilage, and continue upwards behind the costal cartilages to terminate on the left side in the thoracic duct, and on the opposite side in the right lymphatic duct. They receive branches from the upper surface of the liver, and small branches from the anterior parts of the intercostal spaces. The *intercostal* lymphatics, passing backwards in each intercostal space, receive, as they approach the spine, branches coming forward through the intertransverse space, and enter the intercostal glands, through the efferent ducts of which their contents are poured on both sides of the body into the thoracic duct.

The *lymphatics of the lungs*, like those of other organs, form two sets, one being superficial, the other deep-seated. Those at the surface run beneath the pleura, where they form a network by their anastomoses.

Their number is considerable, but they are sometimes difficult of demonstration. The deep lymphatics run with the pulmonary blood-vessels. Both superficial and deep lymphatics converge to the root of the lung, and terminate in the bronchial glands. From these, two or three trunks issue, which ascend along the trachea to the root of the neck, and terminate on the left side in the thoracic duct, and on the right in one of the right lymphatic trunks.

The *lymphatics of the heart* follow the coronary arteries and veins from the apex of the organ towards the base, where they communicate with each other, and those of each side are gathered into one trunk. The trunk from the *right side*, running upwards over the aortic arch between the innominate and left carotid arteries to reach the trachea, ascends to the root of the neck, and terminates in the right lymphatic duct. The vessel from the left side, proceeding along the pulmonary artery to its bifurcation, passes through some lymphatic glands behind the arch of the aorta, and ascends by the trachea to terminate in the thoracic duct.

The *lymphatics of the œsophagus*, unlike those of the rest of the alimentary canal form only one layer, which lies internal to the muscular coat. They are connected with glands in the neighbourhood, and after having communicated by anastomoses with the lymphatics of the lungs, at and near the roots of those organs, they terminate in the thoracic duct.

The *lymphatics of the thymus gland* are numerous. According to Astley Cooper, two large vessels proceed downwards from them on each cornu, and terminate in the jugular veins by one or more orifices on each side. (Anatomy of the Thymus Gland, p. 14.)

LYMPHATICS OF THE UPPER LIMB,

AND OF THE BREAST AND BACK.

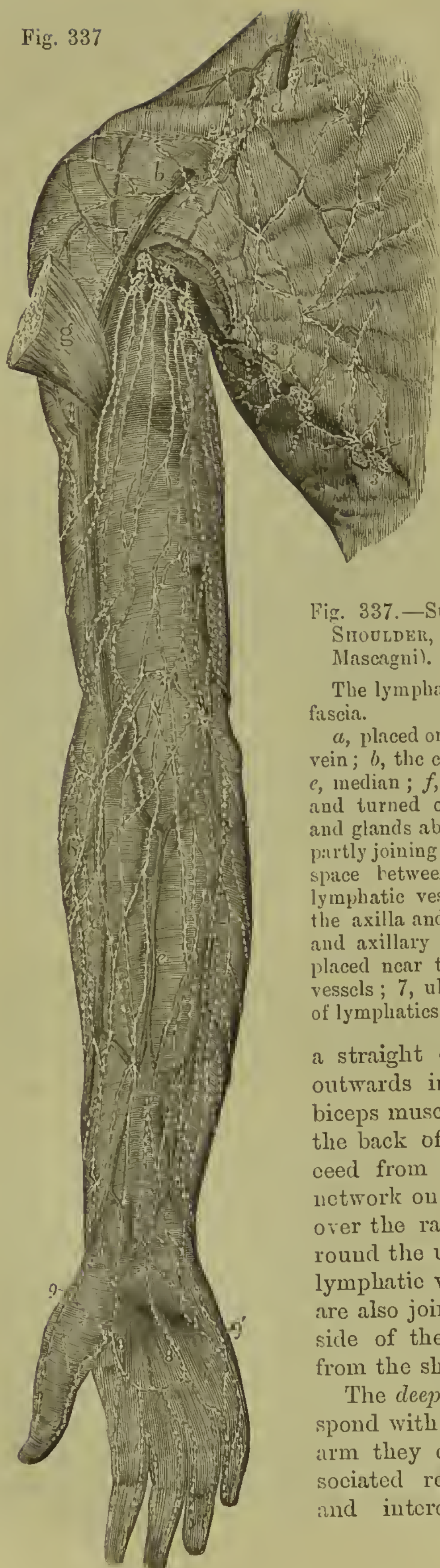
In the upper limb, as in the lower, the lymphatics are arranged in a deep and a superficial set. These two sets of vessels, together with the lymphatics of the surface of the greater part of the back, and those of the mamma and pectoral muscles, converge to the axillary glands.

The lymphatic glands found in the upper limb below the axilla are neither large nor numerous ; a few, however, are found in the course of the brachial artery and even of the arteries of the forearm ; and one or more small glands are found in connection with the superficial lymphatics, lying near the commencement of the basilic vein, a little above and in front of the inner condyle of the humerus.

The *axillary glands* are generally ten or twelve in number : they vary, however, considerably in their number as well as in their size, in different individuals ; they are mostly placed along the axillary vessels, the lower member of this group receiving the lymphatics which ascend from the limb ; but a few lie further forwards on the serratus magnus near the external mammary artery, and beneath the pectoral muscles, and receive lymphatics from the mamma and muscular walls of the chest ; while others incline downwards at the posterior boundary of the axilla, and are joined by the lymphatics from the back.

From the glands of the axilla efferent lymphatic vessels, fewer in number, but larger in size than the afferent vessels, proceed along the course of the subclavian artery, in some parts twining round it. From the top of the thorax they ascend into the neck, close to the subclavian vein, and terminate, —those of the left side in the thoracic duct, those of the right side

Fig. 337



in the right lymphatic duct. Sometimes they unite into a single trunk, which opens separately into the subclavian vein near its termination.

The *superficial lymphatics of the upper limb* are usually described as forming two divisions corresponding with the superficial veins on the outer and inner borders. On the front of the limb they arise from an arch formed in the palm of the hand by the union of two lymphatic vessels proceeding from each finger: becoming more numerous in the forearm, they are found thickly set over its surface, whence they pass upwards in the arm; the inner vessels in

Fig. 337.—Superficial Lymphatics of the Breast, Shoulder, and Upper Limb, from before (after Mascagni). $\frac{1}{5}$

The lymphatics are represented as lying upon the deep fascia.

a, placed on the clavicle, points to the external jugular vein; *b*, the cephalic vein; *c*, the basilic vein; *d*, radial; *e*, median; *f*, ulnar vein; *g*, great pectoral muscle cut and turned outwards; 1, superficial lymphatic vessels and glands above the clavicle; 2, those below the clavicle partly joining the foregoing and dipping into the triangular space between the deltoid and pectoral muscles; 3, lymphatic vessels and glands placed along the border of the axilla and great pectoral muscle; 4, upper brachial and axillary glands and vessels; 5, two small glands placed near the bend of the arm; 6, radial lymphatic vessels; 7, ulnar lymphatic vessels; 8, 8, palmar arch of lymphatics; 9, 9′, outer and inner sets of vessels.

a straight direction, and those placed further outwards inclining gradually inwards over the biceps muscle to reach the axillary glands. On the back of the hand also two lymphatics proceed from each finger; and from the copious network on the back of the forearm vessels pass over the radial margin, and in greater number round the ulnar side to join those in front. The lymphatic vessels in the front of the upper arm are also joined by others which pass round each side of the limb, and by some which descend from the shoulder.

The *deep* lymphatics of the upper limb correspond with the deep blood-vessels. In the forearm they consist, therefore, of three sets, associated respectively with the radial, ulnar, and interosseous arteries and veins. In

their progress upwards some of them have communication near the wrist with the superficial lymphatics; and some of them enter the glands which lie by the side of the brachial artery near the bend of the elbow. They all terminate in the glands of the axilla.

The *lymphatics of the chest* consist of branches running under cover of the pectoral muscles, and of subcutaneous vessels, twigs of which are continued from those on the abdominal wall as low as the umbilicus, decussating with the vessels which converge to the inguinal glands.

The *superficial lymphatics of the back* converge to the axillary glands from its various regions; from the neck over the surface of the trapezius muscle, from the posterior part of the deltoid, and from the whole dorsal and lumbar regions as low as the crest of the ilium; the branches decussating inferiorly with vessels leading to the inguinal glands, and likewise crossing the middle line so as to decussate with branches of the opposite side. (Mascagni, Tab. xxii., xxiii., xxiv.)

LYMPHATICS OF THE HEAD AND NECK.

The *lymphatic glands* found on different parts of the *head* and *face* are few and small: those in the *neck*, on the contrary, are comparatively very large and numerous.

The *cervical glands* are placed chiefly on the sides of the neck, and are divisible into a superficial and a deep series. Of the former, some lie beneath the base of the inferior maxillary bone; the remainder, arranged along the course of the external jugular vein, exist in greatest number in the angular space behind the lower end of the sterno-mastoid muscle, where that vein enters the subclavian vein: at this point the cervical glands approach and are connected with the glands of the axilla. The *deep cervical* glands are placed along the carotid artery and internal jugular vein, extending downwards on the sheath of those vessels as far as the thorax.

The lymphatic vessels of the cranium and face, together with those of the tongue, pharynx, larynx and other parts of the neck, pass into the cervical glands. From these efferent vessels issue, which progressively diminish in number during their descent, and unite into two trunks, of which the left one ends in the thoracic duct, and the other in the right lymphatic duct: sometimes, however, the main cervical lymphatic vessel terminates separately at the junction of the subclavian and internal jugular veins, or in one of those veins immediately before their union.

The *lymphatics of the cranium* consist of a temporal and an occipital set. Those of the *temporal* set descend in front of the ear, some of the vessels passing through one or two glands usually found near the zygoma, whilst others enter those situated on the parotid gland; all of them terminate in the lymphatic glands of the neck. The cranial lymphatics of the *occipital* set, accompanying the occipital artery, descend to the glands situated behind the ear, on and near the mastoid process of the temporal bone, and hence join the superficial lymphatics of the neck.

Within the cranial cavity, lymphatic vessels have been demonstrated in the pia mater and in the arachnoid membrane. None have been traced in the dura mater, nor have they been shown in the substance of the brain. The trunks of those derived from the pia mater pass out of the skull with the veins.

The *superficial lymphatics of the face*, more numerous than those of the

cranium, descend obliquely in the course of the facial vein, and join the submaxillary glands, from six to ten in number, which are placed beneath the

Fig. 338.

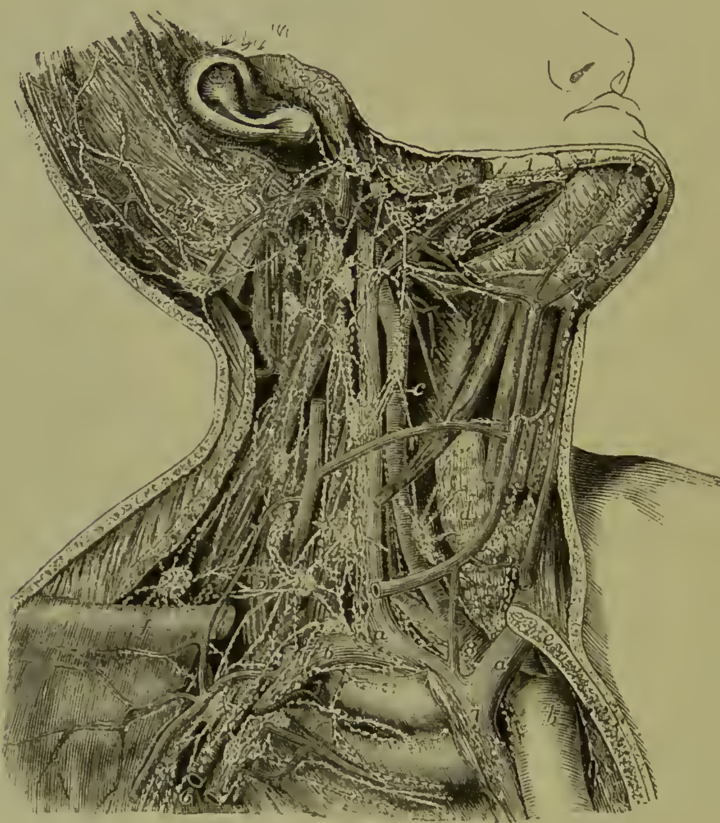


Fig. 338.—Principal Lymphatic Vessels and Glands of the Head and Neck on the Right Side (after Bourgery in part). $\frac{1}{3}$

The inner half of the right clavicle and part of the sternum have been removed so as to expose the arch of the aorta, and the innominate artery and veins: the posterior belly of the omo-hyoid muscle is removed; and the sterno-mastoid, sterno-hyoid, and sterno-thyroid muscles, and a part of the external jugular vein have been divided so as to expose the deeper parts.

a, the right innominate vein at the place where it is joined by the principal lymphatic trunk; *a′*, the left vein; *b*, arch of the aorta; *c*, common carotid artery; *d*, thyroid gland crossed by the anterior jugular vein; *e*, cut surface of the sternum; *f*, outer part of the clavicle; 1, submaxillary lymphatic vessels; 1′, sublingual; 2, temporal, facial and parotid; 3, occipital and posterior auricular; 4, deep or descending cervical close to the great vessels; 5, transverse cervical; 6, deep pectoral and axillary; 7, on the vena cava superior, some of the right mediastinal; 8, on the innominate artery, some of the deeper cardiac and bronchial; to these last are seen descending some of the lymphatics from the thyroid gland and lower part of the neck.

base of the lower maxillary bone; a few of them in their descent pass through some glands situated on the buccinator muscle. The *deep* lymphatics of the *face*, derived from those of the temporal fossa and the cavities of the nose, mouth, and orbit, proceed outwards in the course of the internal maxillary vein; and, having reached the angle of the jaw, they enter the glands in that neighbourhood.

Section V.—NEUROLOGY.

Under the name of Neurology, it is intended to include the descriptive anatomy of the various organs forming parts of the nervous system.

The nervous system consists of two sets of parts, one of which is *central*, the other *peripheral*. To the first set belong the brain and spinal cord, forming together the cerebro-spinal axis, and the ganglia : to the second set belong all the nerves distributed throughout the body ; and along with these may be included the organs of the senses, or those organs which contain the terminations of the several nerves of special sensation, in connection with certain apparatus or modifications of structure related to the reception of impressions by each of these nerves.

Among the peripheral nerves it is necessary also to distinguish the cerebro-spinal and the sympathetic or ganglionic, which, though intimately connected with each other at some places, are yet so different in their structure and mode of distribution as to require separate description.

The description of these several parts of the nervous system will be brought under the following four sub-sections, viz. 1. The cerebro-spinal axis ; 2. The cerebro-spinal nerves and the gauglia connected with them ; 3. The sympathetic nerves and their ganglia ; 4, The organs of the senses.

I.—THE CEREBRO-SPINAL AXIS.

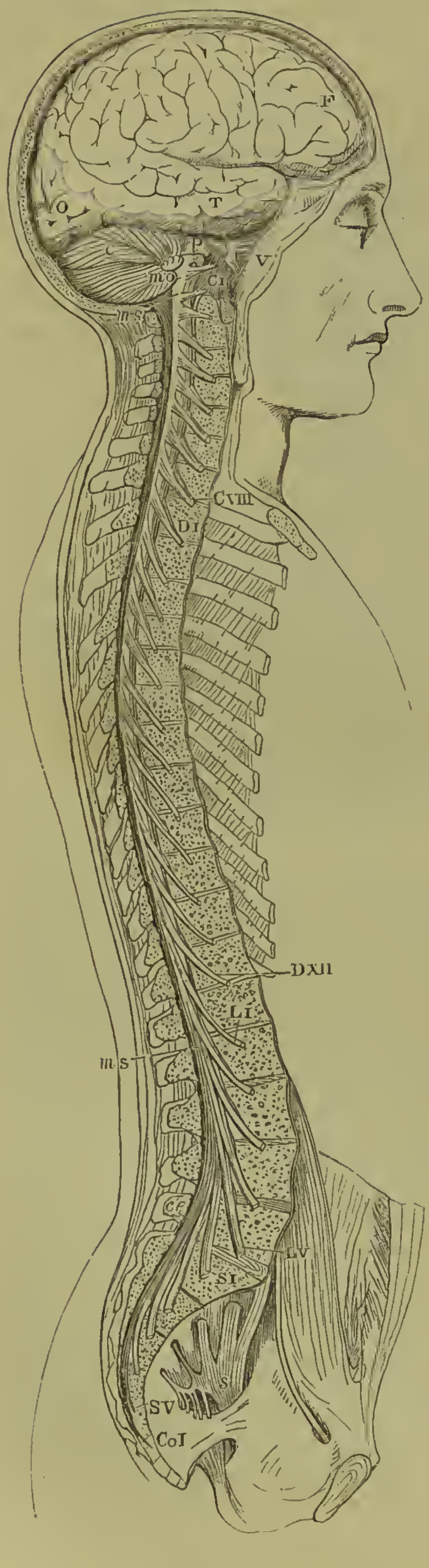
The *cerebro-spinal axis* is contained partly within the cavity of the cranium, and partly within the vertebral canal ; it is symmetrical in its form and structure throughout, consisting of a right and a left half, separated to a certain extent by longitudinal fissures, and presenting in their plane of union various portions of white and grey nervous substance, which cross from one side to another, and form the *commissures* of the brain and spinal cord.

Enclosed within the skull and the vertebral canal, the cerebro-spinal axis is protected by the bony walls of those two cavities ; it is also surrounded by three membranes, which afford it additional protection and support, and are subservient to its nutrition. These envelopes, which will be described hereafter, are, 1st, a dense fibrous membrane named the dura mater, which is placed most superficially ; 2nd, a serous membrane called the arachnoid ; and, 3rd, deepest of all, a highly vascular membrane named the pia mater.

The cerebro-spinal axis is divided by anatomists into the *encephalon* or enlarged upper mass placed within the cranium, and the *spinal cord* contained within the vertebral canal.

These two parts have a relation, one to the other, very similar to that which subsists between the cranium and vertebral column : thus, they are continuous structures ; at the time of their first formation in the fœtus they are nearly similar ; the earliest developed distinction consists in the enlargement of the encephalon ; and, moreover, the spinal cord, like the vertebral column, continues to present a structure nearly uniform throughout its extent, while the encephalon becomes gradually more and more complicated,

Fig. 339.



till at last it is difficult to trace the serial relation of its constituent parts, or any correspondence with the structure of the cord.

Fig. 339.—View of the Cerebro-spinal Axis of the Nervous System (after Bourgery). $\frac{1}{8}$

The right half of the cranium and trunk of the body has been removed by a vertical section; the membranes of the brain and spinal marrow have also been removed, and the roots and first part of the fifth and ninth cranial, and of all the spinal nerves of the right side, have been dissected out and laid separately on the wall of the skull and on the several vertebræ opposite to the place of their natural exit from the cranio-spinal cavity.

F, T, O, lateral surface of the cerebrum; C, cerebellum; P, pons Varolii; *m o*, medulla oblongata; *m s*, upper and lower extremities of the spinal marrow; *c e*, on the last lumbar vertebra, marks the cauda equina; v, the three principal branches of the nervus trigeminus or fifth pair; C I, the suboccipital or first cervical nerve; above this is the ninth pair; C VIII, the eighth or lowest cervical nerve; D I, the first dorsal nerve; D XII, the last or twelfth; L I, the first lumbar nerve; L V, the last or fifth; S I, the first sacral nerve; S V, the fifth; Co I, the coccygeal nerve; *s*, the left sacral plexus.

A.—THE SPINAL CORD.

The *spinal cord*, or *spinal marrow* (medulla spinalis), is that part of the cerebro-spinal axis which is situated within the vertebral canal. It extends from the margin of the foramen magnum of the occipital bone to about the lower part of the body of the first lumbar vertebra. It is continued into the medulla oblongata above, and ends below in a slender filament, the *filum terminale* or *central ligament* of the spinal cord.

Invested closely by a proper membrane (the pia mater), the cord is enclosed within a sheath (theca) considerably longer and larger than itself, which is formed by the dura mater, and which is separated from the walls of the

canal by numerous vascular plexuses, and much loose areolar tissue. The interval between the investing membrane and the sheath of the cord is occupied by a serous membrane (the arachnoid), and the space between the latter membrane and the pia mater is occupied by a fluid called the cerebro-spinal fluid. Within this space the cord is kept in position by proper ligaments, which fix it at different points to its sheath, and by the roots of the spinal nerves,—an anterior and a posterior root belonging to each,—which pass across the space from the surface of the cord towards the intervertebral foramina. From its lower part, where they are closely crowded together, the roots of the lumbar and sacral nerves descend nearly vertically to reach the lumbar intervertebral and the sacral foramina, and form a large bundle or lash of nervous cords named the *cauda equina*, which occupies the vertebral canal below the termination of the cord.

Fig. 340.

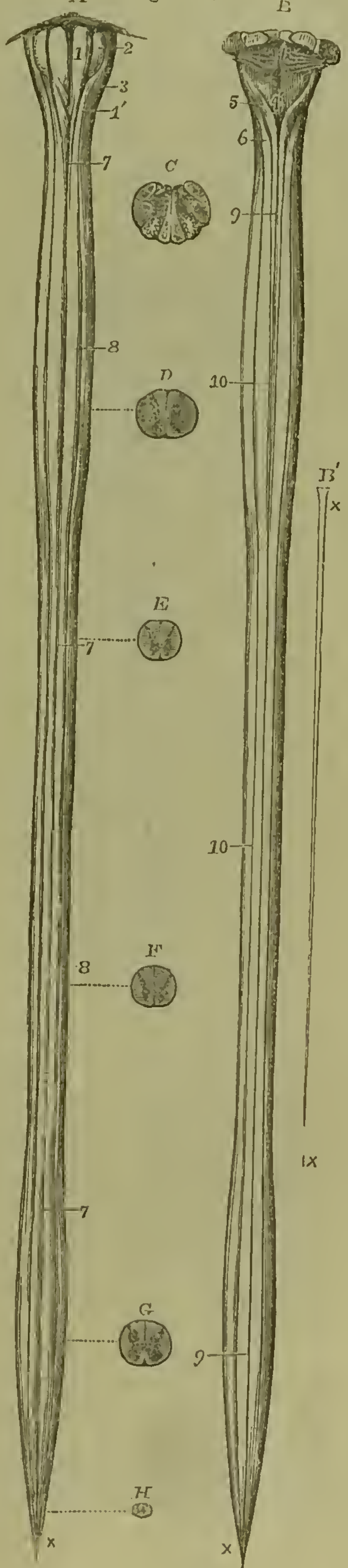


Fig. 340.—Anterior and Posterior Views of the Medulla Oblongata and Spinal Cord with Sections. $\frac{1}{2}$

The cord has been divested of its membranes and the roots of the nerves. A, presents an anterior, B, a posterior view, showing the upper or brachial, and the lower or crural enlargements. In these figures the filiform prolongation, represented separately in B′, has been removed; C, shows a transverse section through the middle of the medulla oblongata; D, a section through the middle of the cervical enlargement of the spinal cord; E, through the upper region of the dorsal part; F, through its lower; G, through the middle of the lumbar enlargement; and H, near the lower end of its tapering extremity.

1, anterior pyramids; 1′, their decussation; 2, olivary bodies; 3, restiform bodies; 4, posterior surface of the medulla oblongata; 4′, calamus scriptorius; 5, posterior pyramids; 6, posterior lateral columns passing up into the restiform bodies; 7, 7, anterior median fissure extending through the whole length of the spinal cord; 8, 8, anterior lateral groove; 9, 9, posterior median fissure; 10, 10, posterior lateral groove; ×, lower end of the tapering extremity of the cord; ×, ×, in B′, the filiform prolongation of the cord and its pia-matral covering.

Although the cord usually ends near the lower border of the body of the first lumbar vertebra, it sometimes terminates a little above or below that point, as opposite to the last

dorsal or to the second lumbar vertebra. The position of the lower end of the cord also varies according to the state of curvature of the vertebral column, in the flexion forwards of which, as in the stooping posture, the end of the cord is slightly raised. In the fœtus, at an early period, the cord occupies the whole length of the vertebral canal; but after the third month, the canal and the roots of the lumbar and sacral nerves begin to grow more rapidly than the cord itself, so that at birth the lower end reaches only to the third lumbar vertebra.

Fig. 341.

A B C

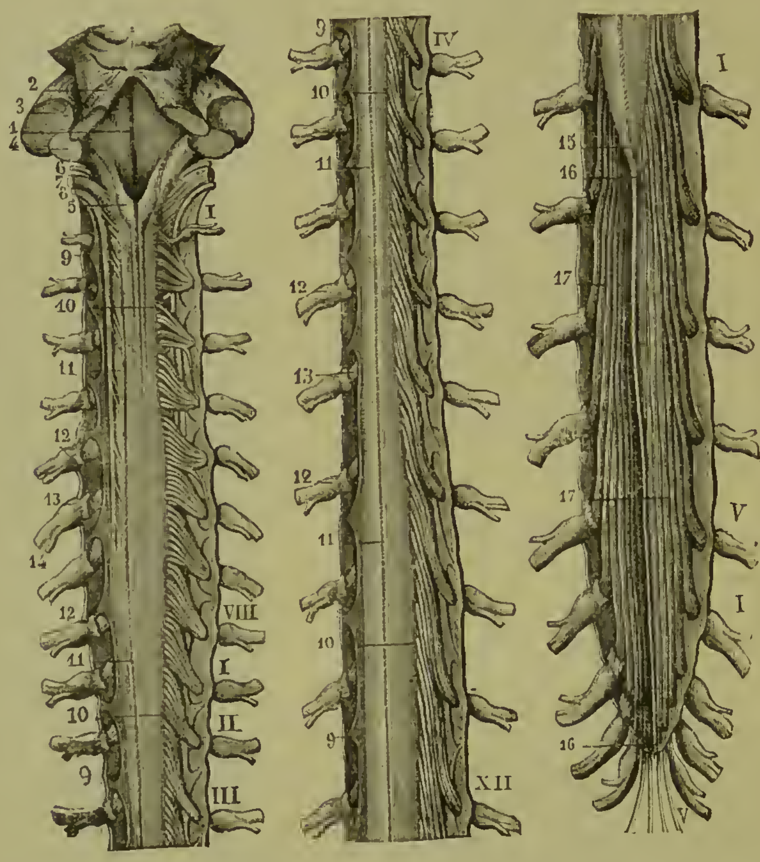


Fig. 341.—Posterior View of the Medulla Oblongata and of the Spinal Cord with its Coverings and the Roots of the Nerves (from Sappey). ½

The theca or dura-matral sheath has been opened by a median incision along the whole length, and is stretched out to each side. On the left side, in the upper and middle parts (A and B), the posterior roots of the nerves have been removed so as to expose the ligamentum denticulatum ; and along the right side the roots are shown passing out through the dura mater. The roman numbers indicate the different nerves in the cervical, dorsal, lumbar, and sacral regions ; 9, several of the pointed processes of the ligamentum denticulatum ; 10, origin of several posterior roots ; 11, posterior median fissure ; 12, ganglia of the spinal nerves ; 13, part of the anterior roots seen on the left side ; 14, the united nerve ; 15, tapering lower end of the spinal cord ; 16, filum terminale ; 17, cauda equina.

The length of the spinal cord is from fifteen to eighteen inches ; and it varies in diameter in different situations. Its general form is cylindrical, somewhat flattened before and behind. It presents two enlargements—an upper or cervical, and a lower or lumbar. The cervical enlargement is of greater size and extent than the lower. It reaches from the third cervical to the first dorsal vertebra ; its greatest diameter is from side to side.

The lower or lumbar enlargement is situated nearly opposite the last dorsal vertebra; its antero-posterior diameter is nearly equal to the transverse. Below this enlargement, the cord tapers in the form of a cone, from the apex of which the small filiform prolongation is continued downwards for some distance within the sheath.

Fig. 342.

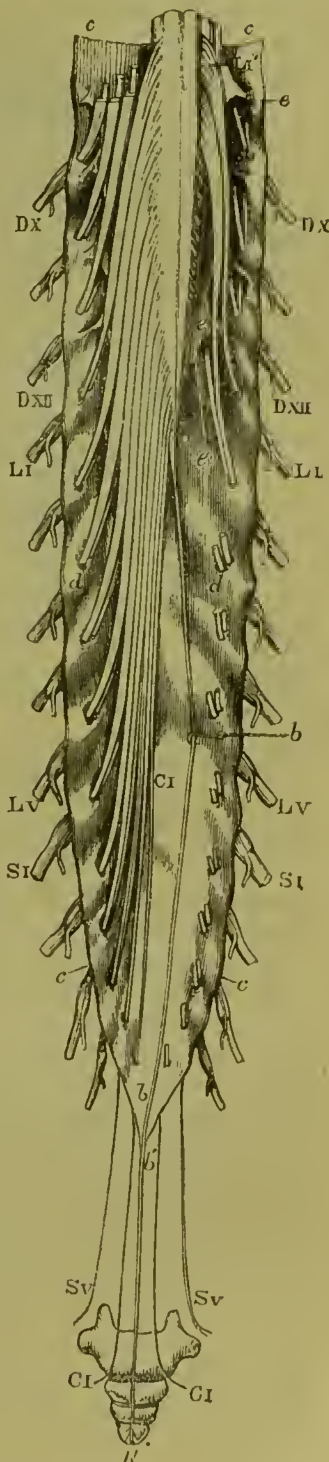


Fig. 342.—Lower Part of the Spinal Cord with the Cauda Equina and Sheath, seen from behind. ½

The sheath has been opened from behind and stretched towards the sides; on the left side all the roots of the nerves are entire; on the right side both roots of the first and second lumbar nerves are entire, while the rest have been divided close to the place of their passage through the sheath. The bones of the coccyx are sketched in their natural relative position to show the place of the filum terminale and the lowest nerves.

a, placed on the posterior median fissure at the middle of the lumbar enlargement of the cord; *b*, *b*, the terminal filament, drawn slightly aside by a hook at its middle, and descending within the dura-matral sheath; *b′*, *b′*, its prolongation beyond the sheath and upon the back of the coccygeal bones; *c*, the dura-matral sheath; *d*, double foramina for the separate passage of the anterior and posterior roots of each of the nerves; *e*, pointed ends of several processes of the ligamentum denticulatum; Dx, and Dxii, the tenth and twelfth dorsal nerves; Li, and Lv, the first and fifth lumbar nerves; Si, and Sv, the first and fifth sacral nerves; Ci, the coccygeal nerve.

The cervical and lumbar enlargements have an evident relation to the large size of the nerves which supply the upper and lower limbs, and which are connected with those regions of the cord,—in accordance with the general fact observed in the animal kingdom, that near the origin of large nerves, the central nervous substance is accumulated in larger proportion. At the commencement of its development in the embryo, the spinal cord is destitute of these enlargements, which, in their first appearance and subsequent progress, correspond with the growth of the limbs.

Sometimes the cord presents one or two bulbs or swellings towards its lower end.

According to Foville, the lumbar enlargement is chiefly due to an increase in bulk of the anterior region of the cord. (Traité compl. de l'Anat., &c., du Syst. Nerv. Cerebro-Spinal. Paris, 1844. Part I., p. 138.)

The *terminal filament* (filum terminale, central ligament) descends in the middle line amongst the nerves composing the cauda equina, and, becoming blended with the lower end of the sheath opposite to the first or second sacral vertebra, passes on to be fixed to the lower end of

the sacral canal, or to the base of the coccyx. Internally, it is a prolongation for about half its length of some of the nervous elements of the cord; externally, it consists of a tube of the pia mater or innermost membrane, which, being attached at its lower end to the dura mater and vertebral canal, keeps pace with the latter in its growth, whilst the cord relatively shortens. It is distinguished by its silvery hue from the nerves amid which it lies. Small blood-vessels may sometimes be seen upon it.

Fissures.—When removed from the vertebral canal, and divested of its membranes, the spinal cord is seen to be marked by longitudinal *fissures.* Of these, two, which are the most obvious, run along the middle line, one in front and the other behind, and are named the *anterior* and *posterior median fissures.*

The *anterior median fissure* is more distinct than the posterior, and penetrates about one-third of the thickness of the cord, its depth increasing towards the lower end. It contains a fold or lamelliform process of the pia mater, and also many blood-vessels, which are thus conducted to the centre of the cord. At the bottom of this fissure is seen the transverse connecting portion of white substance named the *anterior white commissure.*

The *posterior median fissure* is less marked in the greater part of its extent than the anterior, but becomes more evident towards the upper part of the cord. In a certain sense it is no real fissure, except at the lumbar enlargement and in the cervical region, in both of which places a superficial fissure is distinctly visible; for although the lateral halves of the posterior part of the cord are quite separate, there is no distinct reflection of the pia mater between them, but rather a septum of connective tissue and blood-vessels which passes in nearly to the centre of the cord, as far as the *posterior grey commissure.*

Besides these two *median* fissures, two *lateral* furrows or fissures have been described on each side of the cord, corresponding with the lines of attachment of the anterior and posterior roots of the spinal nerves.

The *posterior lateral fissure* is a superficial depression along the line of attachment of the posterior roots, and is at the edge of the plane in which these roots pass inwards to the grey matter of the cord.

The *anterior lateral* fissure, which is often described in the line of the origin of the anterior roots of the nerves, has no real existence as a groove. The fibres of these roots in fact, unlike the posterior, do not dip into the spinal cord in one narrow line, but spread over a space of some breadth. The grey substance of the cord, however, approaches the surface somewhat in the vicinity of the place where the anterior roots enter: and this, together with a slight depression, produces the appearance which has been described as a groove. Thus, each lateral half of the cord is divided by the posterior lateral fissure into a *posterior* and an *antero-lateral* column; and although we cannot trace an anterior lateral fissure, this antero-lateral portion of the cord may, for the convenience of description, be considered as subdivided into an *anterior* and a *lateral column* by the internal grey matter.

On the posterior surface of the cord, and most evidently in the upper part, there are two slightly-marked longitudinal furrows situated one on each side, close to the posterior median fissure, and marking off, at least in the cervical region, a slender tract, named the *posterior median* column. Between the anterior and posterior roots of the spinal nerves, on each side, the cord is convex, and sometimes presents a longitudinal mark corresponding with the line of attachment of the ligamentum denticulatum.

Foville states, that in a new-born child there is a narrow accessory bundle of white

matter, which runs along the surface of the lateral column, and is separated from it by a streak of greyish substance. According to the same authority, this narrow tract enlarges above, and may be traced upwards along the side of the medulla oblongata into the cerebellum. (Op. cit. p. 285.)

Fig. 343.

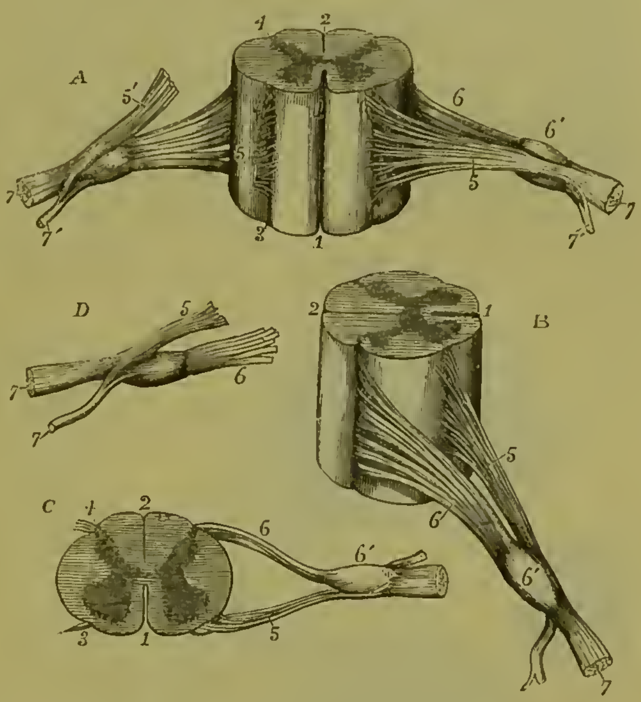


Fig. 343.—Different Views of a Portion of the Spinal Cord from the Cervical Region with the Roots of the Nerves. Slightly enlarged.

In A, the anterior surface of the specimen is shown, the anterior nerve-root of the right side being divided; in B, a view of the right side is given; in C, the upper surface is shown; in D, the nerve roots and ganglion are shown from below. 1, the anterior median fissure; 2, posterior median fissure; 3, anterior lateral depression, over which the anterior nerve-roots are seen to spread; 4, posterior lateral groove, into which the posterior roots are seen to sink; 5, anterior roots passing the ganglion; 5′, in A, the anterior root divided; 6, the posterior roots, the fibres of which pass into the ganglion, 6′; 7, the united or compound nerve; 7′, the posterior primary branch seen in A and D, to be derived in part from the anterior and in part from the posterior root.

Internal structure of the spinal cord.—The spinal cord consists of white and grey nervous substance. The white matter, forming by far the larger portion of the cord, is situated externally, whilst the grey matter is disposed in the interior.

The grey matter, as seen in a transverse section of any part of the cord, presents two crescent-shaped masses, placed one in each lateral half, with their convexities towards one another, and joined across the middle by a transverse portion, the *grey* or *posterior commissure* of the cord. Each of these grey crescents has an *anterior* and a *posterior cornu* or horn. The posterior, generally longer and narrower, approaches the posterior lateral fissure: the anterior, shorter and thicker, extends towards the place of attachment of the anterior roots of the nerves. In front of it a layer of white substance separates it from the bottom of the anterior median fissure, this is named the *anterior white commissure*.

Another white layer, very thin and indistinct, was formerly described as lying behind the grey commissure; but in the present state of our knowledge it seems sufficient to describe one white commissure, and one grey commissure behind it.

At the back part or tip of the posterior horn, which is somewhat enlarged, the grey matter has a peculiar semi-transparent aspect, whence it was named by Rolando *substantia cinerea gelatinosa*: the remaining and

greater part of the grey matter, which resembles that most generally prevalent, was named by Rolando the *substantia spongiosa.*

The grey cornua vary in form in different parts of the cord : thus they are long and slender in the cervical portion, still more slender in the dorsal, and shorter and wider in the lumbar region. The grey matter appears in a series of sections to be, relatively to the white, more abundant in the lumbar region of the cord, less so in the cervical region, and least so in the dorsal. The actual amount, however, of white matter is greatest in the neck. Towards the lower end of the cord, the double crescentic form gradually disappears, and the grey matter is collected into a central mass, which is indented at the sides. At its extreme point, according to Remak and Valentin, the cord consists of grey matter only.

Fig. 344.

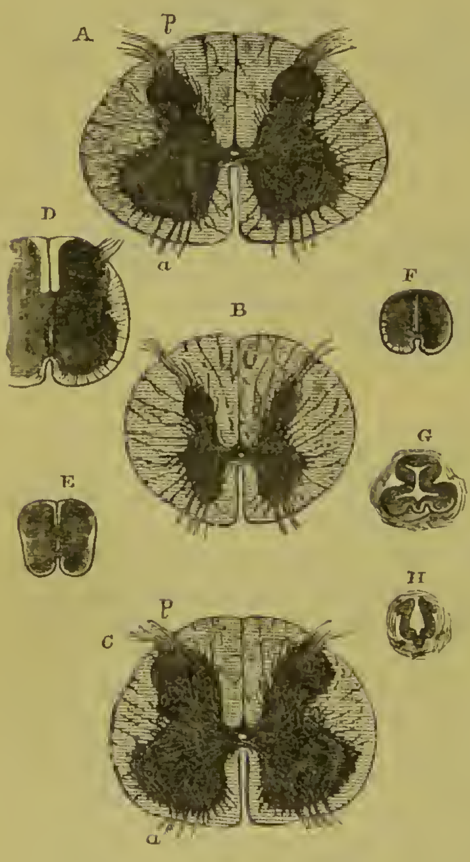


Fig. 344.—Sections of the Spinal Cord in Different Parts.

These views are taken partly from Stilling's plates and partly from nature.

A, is a section through the middle of the cervical enlargement, at the root of the sixth cervical nerve; B, through the middle of the dorsal cylindrical portion ; C, through the middle of the lumbar enlargement ; D, in the conical diminishing part of the cord ; E, farther down at the origin of the fifth sacral nerve ; F, at that of the coccygeal nerve ; G, is a section of the part where the conus medullaris begins to pass into the filum terminale ; and H, at the lower part of this or in the commencement of the filum terminale.

A, B, and C, are fully twice the natural size ; D, E, and F, about three times ; and G and H, about six times. In A, and C, *a*, marks the anterior root-fibres of the nerves ; and *p*, the posterior root-fibres as they enter the spinal cord. In D, E, and F, the great diminution of the white substance in proportion to the grey is seen ; in G, the peculiar form of the central canal and medullary substance covering it ; and in H, the open condition of the central canal posteriorly.

In all the figures the position is the same, viz., the anterior part placed downwards.

Central canal.—Extending through the whole length of the spinal cord, in the substance of the grey commissure, there is a minute central canal which in prepared transverse sections of the cord is barely visible, as a speck, with the naked eye. Superiorly, it is continued into and opens out at the calamus scriptorius of the fourth ventricle ; and inferiorly, it is prolonged into the filum terminale. It is lined with a layer of cylindrical ciliated cells or epithelium. This canal, though minute, is an object of considerable interest as a typical part of the structure of the cord, it being the permanent remains of the cavity of the cylinder formed by the spinal cord at the earliest period of its development. It is more distinctly seen

in fishes, reptiles and birds than in mammals. In the young human subject it is always present, but, according to the observation of Lockhart Clarke and Kölliker, it sometimes disappears in the adult.

Minute structure of the Spinal Cord.—The substance of the spinal cord consists of a large proportion of nervous substance, supported in a delicate framework of connective tissue and numerous minute blood-vessels. The white matter presents nerve-fibres, but is destitute of nerve-cells; the grey matter contains both elements. The fibres of the white substance are in greatest part longitudinal; the principal exceptions being those contained in the commissure, and in the roots of the nerves. The longitudinal fibres are finer in the posterior columns and posterior parts of the lateral columns than in other parts, and the deepest fibres are smaller than those placed more superficially. (Kölliker.) The fibres of the grey substance are for the most part not more than one half the diameter of their continuations in the white substance, and in the nerve-roots, but among them there are a few of larger size. They are very various in their direction, and, in great part at least, are connected with the roots of the nerves.

Fig. 345.

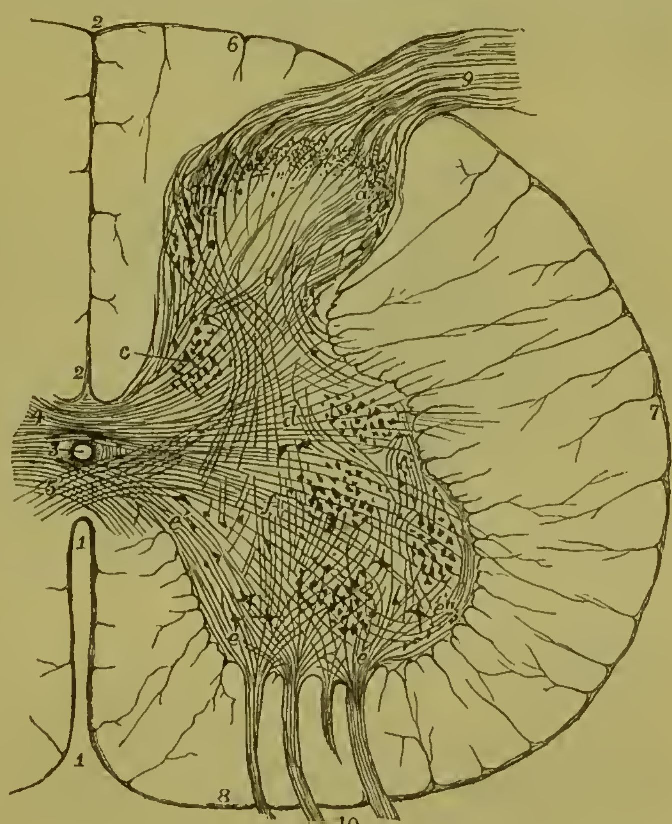


Fig. 345.—Transverse Section of half the Spinal Marrow in the Lumbar Enlargement. $\frac{8}{1}$

This is a semidiagrammatic representation taken from a prepared specimen, and founded in part on the statements of Lockhart Clarke, and of Kölliker. 1, anterior median fissure; 2, posterior median fissure; 3, central canal lined with epithelium; 4, posterior commissure; 5, anterior commissure; 6, posterior column; 7, lateral column; 8, anterior column; (at each of these places and throughout the white substance the trabecular prolongations of the pia mater are shown;) 9, posterior roots of the spinal nerve entering in one principal bundle; 10, anterior roots entering in four spreading bundles of fibres; *a*, *a*, caput cornu posterioris with large and small cells, and above them the gelatinous substance; *b*, in the cervix cornu, decussating fibres from the nerve roots and posterior commissure; *c*, posterior vesicular columns (of Clarke); *d*, fibres running transversely from the posterior commissure into the lateral columns: near *d*, the lateral group of cells; *e*, *e*, fibres of the anterior roots entering the anterior cornu, and passing through among the radiating cells, but not joining their processes; *e'*, fibres from the anterior roots which decussate in the anterior column; *e''*, external fibres from the roots running round the outside of the anterior grey cornu towards the lateral columns; *f*, fibres from the posterior commissure and from the posterior cornu running towards the anterior. Three groups of cells are seen in the anterior column; of these the anterior are external and internal, the posterior are chiefly external or lateral.

The nerve cells of the grey matter are of two kinds. Firstly, there are very large branched cells, from $\frac{1}{400}$ to $\frac{1}{200}$ of an inch in size, containing nuclei and pigment; secondly, there are smaller cells, ranging from $\frac{1}{3000}$ to $\frac{1}{400}$ of an inch, but the majority are from $\frac{1}{1200}$ to $\frac{1}{600}$ of an inch in size.

The smaller cells occur scattered throughout the whole of the grey matter; the larger cells, on the contrary, are collected into groups. In the posterior cornua the large cells are almost entirely collected into a compact group, the *posterior vesicular column* of Clarke (the core of Stilling), which occupies the inner half of the cervix of the posterior cornu. This vesicular column is in intimate connection with the posterior roots of the nerves; it may be traced continuously from near the lower extremity of the spinal cord to the middle of the cervical enlargement, where it terminates; and it increases in size in both the lumbar and cervical enlargements. In the anterior cornu the large cells occur in greater number than in the posterior cornu, and are of somewhat greater size; and they are principally placed at its forepart, and arranged in an inner and an outer group. There is likewise described by Clarke a small group of cells, collected in a *tractus intermedio-lateralis*, and forming a projection of the grey matter opposite the junction of the anterior and posterior cornua. This lateral vesicular column extends from the upper part of the lumbar to the lower part of the cervical enlargement; and it may be said to reappear at the upper extremity of the cord, where it is traversed by the roots of the spinal accessory nerve, and is continued up into the medulla oblongata.

Fig. 346.

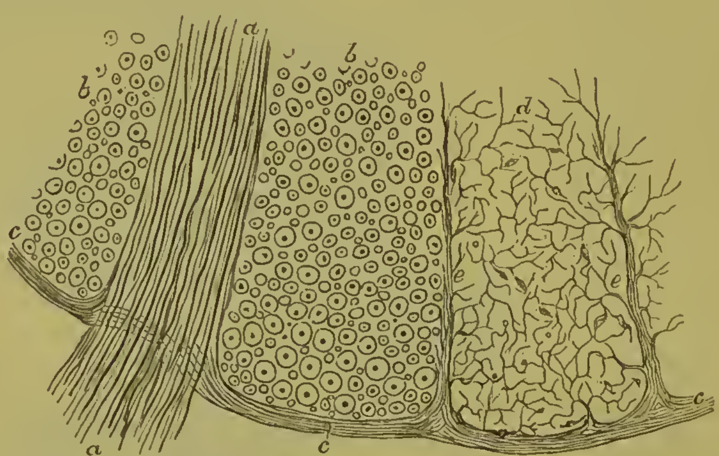


Fig. 346.—A Small Portion of a Transverse Section of the Human Spinal Cord near the Surface at the entrance of a Bundle of the Anterior Roots. $\frac{200}{1}$

This figure, which is somewhat diagrammatic, is intended to show the relation to the nervous substance of the pia-matral sheath of the cord and the processes of connective tissue prolonged from it between the longitudinal and other nerve fibres. *a*, *a*, the primitive filaments of a bundle of the anterior roots, the medullary sheaths not represented; *b*, *b*, transverse sections of part of the anterior columns of the cord, in which the dark points are the primitive filaments, and the circles represent the neurilemmal tube enclosing the medullary substance: in these parts the connective tissue is not represented, and many of the smallest nerve fibres have also, for the sake of clearness, been omitted; *c*, the pia-matral covering of the cord; *d*, one of the compartments of the anterior column enclosed by septa of connective tissue prolonged from the pia-mater, and exhibiting the fine frame-work of connective tissue extending through among the nerve fibres, which last have been omitted: there are also indicated among the trabeculæ minute nuclei of connective tissue.

Connective tissue takes part in the structure of the cord to a very considerable extent. It forms a complete covering surrounding the white substance. In the inner margin also of the posterior columns, one on each side of the posterior fissure, two wedge-shaped bands (the *bands of Goll*) have been distinguished, in which the

connective tissue is remarkably abundant, and the nerve fibres particularly small. The connective tissue forms also a *reticulum* (processus reticularis), in which the longitudinal nerve fibres are imbedded. In the grey matter the connective tissue is still more abundant, more especially in the immediate neighbourhood of the central canal. Much discussion has taken place as to whether the smallest cells already described are really nervous or belong to the connective tissue. In the present imperfect state of knowledge of the development of nervous elements, it might be rash to express a decided opinion on this point; but it may be stated that, independent of these, nuclei are figured by Kölliker in the reticulum, and also cells containing numerous and dividing nuclei in the neighbourhood of the central canal.

Origin of the spinal nerves.—The anterior and posterior roots of the spinal nerves are attached along the sides of the cord in or near the anterior and posterior lateral grooves, and opposite to the corresponding cornua of the grey matter; the posterior roots in a straight line, and the anterior roots scattered somewhat irregularly upon the surface (Fig. 345).

The fibres of the *anterior roots* may be traced into and through the anterior cornua. They then diverge in different directions. The innermost fibres, after passing through among the cells in the inner group of the anterior cornu, cross in the white commissure to the anterior column of the opposite side. Many fibres pass backwards in the substance of the anterior cornu where some of them would appear to form connection with fibres proceeding from other parts of the cord, and others to spread obliquely upwards and downwards; while those which are most external, passing through the outer group of cells, reach the lateral column.

Fig. 347.

Fig. 347.—A Small Portion of a Transverse Section of the Spinal Cord at the place where two bundles of the Fibres of the Anterior Roots pass into the grey substance. $\frac{300}{1}$

This figure may be looked upon as representing the inner ends of the anterior roots of the nerves, of which the outer part is shown in fig. 348. *a*, *a*, the two bundles of fibres of the anterior root passing between the compartments of longitudinal fibres of the cord; *b*, *b*, these fibres running backwards through the grey substance towards the posterior cornua; *c*, *c'*, those spreading in the anterior cornua on the one side towards the anterior commissure, and on the other round the outer side of the anterior cornu; *d*, *d*, portions of three compartments of the anterior columns in which the longitudinal fibres of the cord are shown in transverse section; *e*, *e*, large radiated and nucleated cells in the grey substance of the anterior cornu—some with three, others with a greater number of processes emanating from them: no direct communication is shown between these processes and the nerve fibres of the roots.

The fibres of the *posterior roots* on reaching the posterior cornu diverge from each other in a curved manner, so as to form in great part the substantia gelatinosa. In front of this there may be seen, cut across in transverse sections, a group of these fibres which turn longitudinally upwards and downwards, and afterwards pass forwards, in part at least, to the anterior cornu, and in part to reach by the posterior commissure the posterior and lateral columns of the opposite side. Other fibres of the posterior roots pass forwards at once through the grey substance to the anterior

and lateral columns. Another set of fibres slant principally upwards, but some downwards, in the posterior columns, and, interlacing with each other, most probably enter the grey matter at different heights. Some are lost to view in the posterior white columns, and it is uncertain whether or not they immediately ascend through these columns to the brain.

Much discussion has taken place as to the course of the fibres in the cord, and their ultimate destination. It is easily understood that by the examination of sections difficult to prepare, limited in extent, liable to undergo changes in the preparation, and giving views confined each to little more than a thin lamina, it is scarcely to be expected that the full history of many tortuous fibres can be accurately ascertained. Thus it remains still undecided whether any of the fibres of the nerve-roots pass up all the way to the brain. Volkmann concluded that none of them reached the brain, arguing from measurements of the size of the cord in different regions, that the cord could not contain in its upper regions all those nerve-fibres which were traceable to it in the lower. Kölliker pointed out the fallacy of this conclusion in so far as Volkmann had not made proper allowance for the diminished size of the fibres as they ascend in the cord; but although Volkmann's argument was thereby invalidated, it appears impossible to prove by microscopic observations that fibres of nerve-roots traced into the grey matter, and observed to emerge into the white matter, do not again re-enter the grey, and terminate there. (Lockhart Clarke, Phil. Trans., 1851, 1853, 1859; Stilling, Neue Unters. u. d. Bau des Rückenmarks, 1856, 1857; Lenhossec, Neue Unters. u. d. Bau d. cent. Nervensystems, Vienna, 1855; F. Goll, Beitrage z. feineren Bau d. Rückenmarks, Zurich, 1860. For a full account of the whole subject, see Kölliker's Handbuch der Gewebelehre des Menschen, 4th ed., 1863).

It is also undetermined in what relation the nerve-fibres and branched or multipolar cells of the cord stand to each other. Most are inclined to believe that the radiating prolongations of the cells are in actual continuity with the axial filaments of nerve fibres, whether proceeding from nerve-roots or from different parts of the cord itself; and the direct observation of such continuity has been affirmed by some, as by Schroeder Van der Kolk. But it is still considered by observers who have given most careful attention to this investigation that, although such continuity may be regarded as of the greatest probability, and although it may be considered as proved in some other parts of the nervous system, especially in the lower animals, the actual passage of nerve-fibres into the processes of nerve-cells has not been proved as the result of actual observation in the spinal cord of man or of mammals.

Results of Experiments.—Seeing the imperfect nature of the knowledge of the minute structure of the spinal cord as obtained from microscopic observations, it may be proper to give here a short account of the more important results of physiological experiments as to the course of the transmission of sensory impressions and motor influences through it, although it is at present difficult to reconcile them with the results of anatomical research. For the most important information upon this subject, derived from vivisection, science is indebted to the researches of Brown-Séquard and Schiff.

When the superior or dorsal * half of the cord is divided in animals, sensation still continues in the hind limbs. Sensation likewise continues after division of the inferior half of the cord, and even after the superior and inferior parts of the cord have been divided at different levels in such a manner that the hinder extremity of the cord may be supposed to communicate with the brain by means of the central grey matter only. But sensation is abolished by piercing the interior of the cord with an instrument, and so moving it as to divide as much as possible the grey matter without injuring the white matter. Moreover, section of the cord and irritation of the cut surfaces produce no pain, provided that the plane of section be sufficiently removed from the origins of nerves, as may be accomplished in the cervical region; but in the neighbourhood of nerve roots there is great sensibility. From all these circumstances it appears probable that the sensory fibres, viz., those of the posterior roots, pass quickly into the grey substance, and that the grey substance conducts sensory impressions upwards. Moreover, the circumstance that the posterior as well as the anterior surfaces of transverse sections made near the nerve roots are sensitive seems

* The student is reminded that "superior" applied to animals corresponds to "posterior" applied to the human subject.

to be accounted for by the curving of the nerve roots, both toward and away from the brain. By similar experiments, it is made probable that motor impressions likewise travel chiefly in the grey matter of the cord.

Section of one lateral half of the cord is followed by loss of sensation in the opposite hind limb, and of motion in the limb of the side operated on: and a prolonged mesial incision produces loss of sensation in both hind limbs, without paralysis of motion. But in the medulla oblongata, before the decussation of the anterior pyramids, section of one side produces loss of both sensation and motion on the opposite side. From these circumstances it appears probable that the sensory fibres, viz., those of the posterior roots, decussate in the commissure of the spinal cord, while the motor fibres, those derived from the anterior roots, cross chiefly at the decussation of the anterior pyramids of the medulla oblongata. (For further details, see Brown-Séquard, "Central Nervous System," 1860; also, for a succinct account of the subject and for bibliography, J. Béclard, "Physiologie Humaine," 4th ed., 1862; "Carpenter's Human Physiology, 6th edit., 1865).

B.—THE ENCEPHALON.

The encephalon admits of being conveniently divided into the medulla oblongata, the cerebellum with the pons Varolii, and the cerebrum.

Fig. 348.

Fig. 348.—Plan in outline of the Encephalon, as seen from the right side. ⅓

The parts are represented as separated from one another somewhat more than natural so as to show their connections. A, cerebrum; *f*, *g*, *h*, its anterior middle and posterior lobes; *e*, fissure of Sylvius; B, cerebellum; C, pons Varolii; D, medulla oblongata; *a*, peduncles of the cerebrum; *b*, *c*, *d*, superior, middle, and inferior peduncles of the cerebellum; the parts marked *a*, *b*, *c*, C, form the isthmus encephali.

The *medulla oblongata* is the part continuous with the spinal cord: it rests on the basilar process of the occipital bone, and on its superior or dorsal surface presents a groove continuous with the central canal of the spinal cord.

The *cerebellum* occupies the posterior fossa of the cranium. By the mesial part of its anterior and inferior surface, it forms the roof of a space,

the floor of which is the grooved posterior surface of the medulla oblongata, and which is named the fourth ventricle of the brain. On each side of this, the cerebellum is connected with the medulla oblongata and cerebrum, and also receives the fibres of the *pons Varolii*, which is a commissure passing beneath and between the fibres which extend upwards from the medulla oblongata, so as to unite the two lobes of the cerebellum.

The *cerebrum* includes all the remaining and much the largest part of the encephalon. It is united with the parts below by a comparatively narrow and constricted portion or isthmus, part of which, forming the crura cerebri, descends into the pons Varolii, and through it is continued into the medulla oblongata, whilst another part joins the cerebellum. Situated on the fibres which extend up from the constricted part, are a series of eminences, named, from behind forwards, the corpora quadrigemina, optic thalami, and corpora striata ; and springing from the front and outer side of the corpora striata are the large convoluted cerebral hemispheres, which expand from this place in all directions, concealing the eminences named, and occupying the vault of the cranium, the anterior and middle cranial fossæ, and the superior fossæ of the occipital bone. The cerebral hemispheres are united together by commissures ; by means of which there is enclosed a cavity, which is subdivided into various ventricles, viz., the two lateral, the third, and the fifth.

THE MEDULLA OBLONGATA.

The *medulla oblongata* is bounded above by the lower border of the pons Varolii, whilst it is continuous below with the spinal cord, on a level with the upper border of the atlas, at a point which corresponds with the lower extremity of the anterior pyramids, to be presently described. It inclines obliquely downwards and backwards ; its anterior surface rests in the basilar groove, whilst its posterior surface is received into the fossa named the vallecula, between the hemispheres of the cerebellum, and there forms the floor of the fourth ventricle. To its sides several large nerves are attached.

The term medulla oblongata, as employed by Willis, by Vieussens, and by those who directly followed them, included the crura cerebri and pons Varolii, as well as that part between the pons and the foramen magnum, to which, by Haller first, and by most subsequent writers, this term has been restricted.

It is of a pyramidal form, having its broad extremity directed upwards : it is expanded laterally at its upper part : its length from the pons to the lower extremity of the pyramids is about an inch and a quarter ; its greatest breadth is nearly an inch ; and its thickness, from before backwards, is about three quarters of an inch.

The *anterior* and *posterior mesial fissures* which partially divide the spinal cord are continued up into the medulla oblongata. The anterior fissure terminates immediately below the pons in a recess, the *foramen cæcum* of Vicq d'Azyr ; the posterior fissure is continued upwards into the floor of the fourth ventricle, where it opens and expands in a superficial furrow, and is gradually lost.

In other respects an entirely different arrangement of the parts prevails from that in the cord. The surface of each half of the medulla presents four eminences or columns, which are met with in the following order, from before backwards, viz. : the anterior pyramids, the olivary bodies, the restiform bodies, and the posterior pyramids.

The *anterior pyramids* are two bundles of white substance, placed one on either side of the anterior fissure, and marked off from the olivary body externally by a slight depression. They become broader and more prominent as they ascend towards the pons Varolii. At their upper end they are constricted, and thus enter the substance of the pons, through which their fibres may be traced into the peduncles of the brain.

Fig. 349.

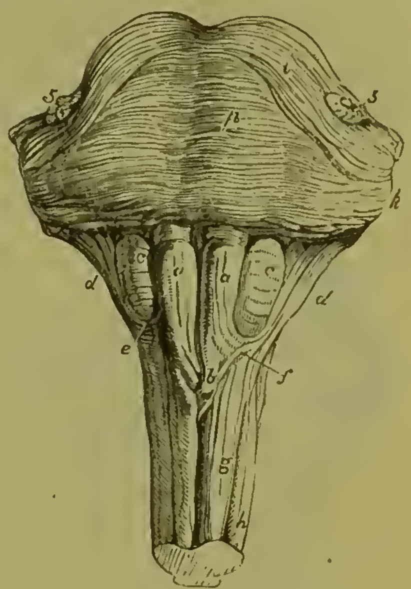


Fig. 349.—View of the Anterior Surface of the Pons Varolii and Medulla Oblongata.

a, *a*, anterior pyramids ; *b*, their decussation ; *c*, *c*, olivary bodies ; *d*, *d*, restiform bodies ; *e*, arciform fibres ; *f*, fibres described by Solly as passing from the anterior column of the cord to the cerebellum ; *g*, anterior column of the spinal cord ; *h*, lateral column ; *p*, pons Varolii ; *i*, its upper fibres ; 5, 5, roots of the fifth pair of nerves.

In the lower part, a portion of each pyramid, arranged in several bundles, which interlace with the corresponding bundles of the other pyramid, passes downwards across the fissure to the opposite side. This *decussation of the pyramids* is not complete, but affects much the greater part of the innermost fibres. When traced from below, it is found that the whole or a great part of the decussating fibres come forward from the deep portion of the lateral columns of the cord, and advance to the surface between the diverging anterior columns, which are thus thrown aside. (Rosenthal, " Beitrag zur Encephalotomie," 1815.)

The outer smaller portion of each pyramid does not decussate ; it consists of fibres, derived from the anterior column of the cord : these ascend, and are joined by the decussating portion from the opposite side. Together they form a prismatic bundle or column of white fibres, which extends deeply into the substance of the medulla, and is triangular in a cross section.

The anterior pyramids contain no grey matter.

The *olivary bodies* are two prominent oval masses placed to the outer side of the pyramids, and sunk to a considerable depth in the substance of the medulla oblongata, appearing on its surface like two smooth oval eminences. They do not reach the pons Varolii above, being separated from it by a deep depression ; nor do they extend so far in a downward direction as the pyramids, being considerably shorter than those bodies.

The olivary bodies consist externally of white substance, of which the fibres chiefly run longitudinally ; and internally of a grey nucleus, named *corpus dentatum* or *ciliare*, or *olivary nucleus*.

The *olivary nucleus* appears, on making a section, whether horizontal or vertical, through the middle, to present the form of a zig-zag line of a light yellowish colour, circumscribing a whitish substance within, and interrupted towards the centre of the medulla. It is arranged in the form of a capsule, which is open at its upper and inner part and has its sides corrugated or

plicated, so as to give the indented appearance to a section. This capsule is, moreover, surrounded with white matter externally, and through its open part white fibres pass into or issue from its interior, and connect it with other parts of the brain. The external fibres of the anterior columns of the cord, which at the decussation of the pyramids are thrown outwards, are continued upwards, on the surface of the medulla oblongata, and then pass partly on the outside of and partly beneath the olivary bodies—being joined in their further progress by the fibres issuing from the olivary nucleus. To these fibres the term *olivary fasciculus* has been applied.

The *restiform bodies*, placed behind and to the outer side of the olivary bodies, are two lateral rounded eminences or columns directly continuous with the posterior, and with part of the antero-lateral columns of the cord; they diverge slightly as they ascend, and thus occasion the greater width of the medulla at its upper part. Each of them passes into the corresponding hemisphere of the cerebellum, and constitutes its inferior peduncle. At first they are in contact with the small tracts of the medulla, named the posterior pyramids; but higher up they become free and prominent, and assist in forming the lateral boundaries of the fourth ventricle. There is a considerable portion of grey matter in their interior.

Fig. 350.

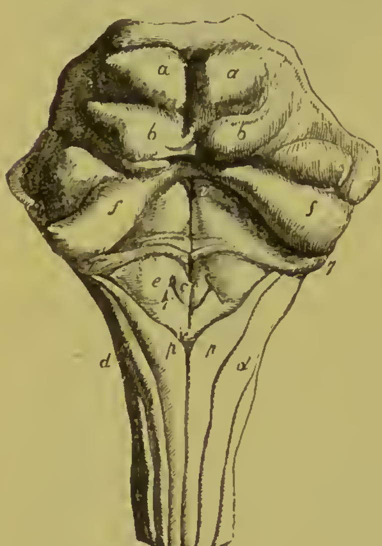


Fig. 350.—View of the Posterior Surface of the Pons Varolii, Corpora Quadrigemina, and Medulla Oblongata.

The peduncles of the cerebellum are cut short at the side. *a*, *a*, the upper pair of corpora quadrigemina; *b*, *b*, the inferior; *f*, *f*, superior peduncles of the cerebellum; c, eminence connected with the nucleus of the hypoglossal nerve; *e*, that of the glosso-pharyngeal nerve; *i*, that of the vagus nerve; *d*, *d*, restiform bodies; *p*, *p*, posterior pyramids; *v*, *v*, groove in the middle of the fourth ventricle; *v*, calamus scriptorius, and eminence connected with the spinal accessory nerve; 7, 7, roots of the auditory nerves. (See also Fig. 359, at p. 525.)

By far the larger portion of the white substance of the restiform body consists of longitudinal fibres, which include all those belonging to the posterior column of the cord except the fasciculus gracilis, some derived from the lateral column, and also a small band from the anterior column. This last-named band runs obliquely below the olivary body and, as was shown by Solly, connects the anterior column with the cerebellum.

The part of the posterior column of the cord which belongs to the restiform body of the medulla, is named *fasciculus cuneatus*.

The *posterior pyramids* (fasciculi graciles) of the medulla oblongata, the smallest of the four pairs of columns into which it is divided, are situated one on either side of the posterior median fissure. They consist entirely of white fibres, and are continuous with the posterior slender tracts of the cord. They increase in size as they ascend till they reach the point where the medulla opens out to form the floor of the fourth ventricle; and there, diverging from one another, they have the appearance of tapering and become closely applied to the restiform bodies. Their fibres quit these bodies, however, and pass up to the cerebrum.

The *floor of the fourth ventricle*, or space between the medulla and cerebellum, is formed by that portion of the back of the medulla oblongata which is situated above the divergence of the posterior pyramids. Upon it, the central grey matter of the medulla oblongata, is, as it were, opened out to view. It is marked by a median furrow, ending inferiorly in the *calamus scriptorius*, and at its lower end is a tubular recess, passing down the centre of the medulla for a few lines. This, which has been sometimes named the *ventricle of Arantius*, is the upper expanded portion of the central canal of the spinal cord.

In the upper part of the floor of the fourth ventricle are two longitudinal eminences, one on each side of the middle furrow, greyish below, but appearing white higher up. These are formed by two bundles of white fibres, mixed with much grey matter, the *fasciculi teretes* of some authors, *les faisceaux innominés* of Cruveilhier. They seem to be derived from part of the lateral columns of the cord; Cruveilhier believes, however, that they arise from the grey matter at the lower end of the medulla oblongata.

Surmounting the free inner margin of the restiform body and posterior pyramid is a thin lamina, the *ligula* (smaller pons of Meckel) occupying the angle between the cerebellum and the restiform body, and stretching towards its fellow of the opposite side. It derives a certain interest from indicating how the cylinder, which is closed in the spinal cord, might be completed in this region of the medulla oblongata by the union of the opposite margins.

Crossing the grey matter in the floor of the fourth ventricle several transverse white lines, or striæ, are usually observed, passing outwards from the median fissure, and round the sides of the restiform bodies. Some of these white striæ form part of the roots of the auditory nerves, a few run slantingly upwards and outwards on the floor of the ventricle, whilst others again embrace the corresponding half of the medulla oblongata. These transverse lines are sometimes wanting, in which case the white fibres on which they depend probably exist at some depth below the surface.

Santorini, and subsequently Rolando, described a set of superficial white fibres on the fore part and sides of the medulla oblongata, crossing over it below the olivary bodies, *fibræ vel processus arciformes*. They belong to a system of white fibres which pass transversely or horizontally outwards, and are probably continuous with the septal fibres about to be noticed. Sometimes the greater part of the pyramidal and olivary bodies is covered by a thin stratum of these transverse fibres, which appear to issue from the anterior median fissure; but, most commonly, these superficial fibres are found only at the lower extremity of the olive, as the arciform fibres already mentioned.

Besides the superficial transverse fibres now referred to, the medulla oblongata presents other horizontal fibres in its interior, some of them disposed in a mesial *raphe* or *septum*, and numerous others proceeding from that septum transversely outwards. Of these last, the majority, passing through the olivary bodies, and in part the pyramids, enter the corpus dentatum and form the whole of its white substance; and these fibres, then passing radiately through the grey capsule, turn backwards to the fasciculus cuneatus and lateralis, those of them which pierce the anterior wall of the capsule arching round it to reach their destination. Other fibres pass behind the olivary into the restiform bodies, and seem to terminate in the grey substance of the floor of the fourth ventricle. (See Kölliker's Handbuch der Gewebelehre, 1863, p. 316.)

A small band of fibres is represented by Reichert as passing obliquely downwards and backwards from the side of the pons Varolii, descending between the auditory and facial nerves, and crossing over the upper end of the posterior pyramids. He names it the *ala pontis*. It probably is part of the ligula. (Reichert, Bau des Menschl. Gehirns, part 1st, plate I., 1859).

Course of fibres from the spinal cord upwards through the medulla oblongata.—Assuming, for convenience of description, the existence of three white columns of the cord, these are disposed as follows.

1. The *posterior column*, with the exception of the fasciculus gracilis, is distinguished by the name of processus cuneatus and enters into the formation of the restiform body, which ascends to the cerebellum. The fasciculus gracilis ascends to the cerebrum.

2. The *lateral column* ascends towards the base of the olivary body, and is disposed of in three ways; (1,) some of its fibres from the surface and deep part join the restiform body and proceed with it to the cerebellum; (2,) a larger number, passing obliquely inwards, then come forwards between the anterior columns, and crossing the median plane appear as the fibres of decussation, and form the chief part of the opposite anterior pyramid; (3,) the remaining fibres pass up to the cerebrum, as the fasciculi teretes

Fig. 351.

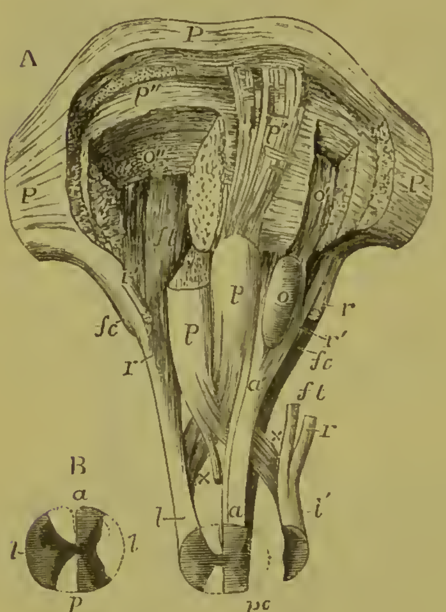


Fig. 351.—Diagrammatic Representation of the Passage of the Columns of the Medulla Oblongata upwards and downwards.

A, the specimen, which is seen from before, includes the medulla oblongata and the pons Varolii, with a small portion of the spinal marrow. The left lateral column (that to the readers right) has been lifted out of its place to the side, and the anterior and posterior columns of that side remain undisturbed: the right anterior and posterior columns have been removed, and the lateral column remains in its place. The upper part of the right pyramid is removed. The transverse fibres of the pons Varolii have been divided in circumscribed portions to different depths corresponding with the several places of passage of the columns of the medulla.

P, pons Varolii, part of the anterior surface, where it has been left entire; *p*, the right and left pyramids, the upper part of the right has been cut away; *p′*, the fibres of the left pyramid as they ascend through the pons exposed by the removal of the superficial transverse fibres; *p″*, placed on the deeper transverse fibres of the pons on the right side, close below the divided fibres of the pyramid; *a*, left anterior column of the cord, passing upwards into the undecussated part of the anterior pyramid, and into *a′*, the olivary column; *o*, olivary body; *o′*, the continuation of the olivary column ascending deeply through the pons, and exposed by the removal of a small portion of the deeper transverse fibres; *o″*, the same fibres divided by a deeper incision on the right side; *l*, the right lateral column, passing upwards into the following parts, viz., ×, the deeper part passing by decussation into the left pyramid; *r*, the part passing into the restiform body; *ft*, the part ascending in the back of the fourth ventricle as fasciculus teres; to the outer side of this are seen the ascending fibres of the posterior pyramid; *l′*, the left lateral column drawn aside from its place in the spinal cord; the fasciculus teres, *ft*, and the part to the restiform body, *r*, cut short; ×, the deeper part passing by decussation into the right pyramid; *r′*, the part of the restiform body derived from the anterior column of the spinal cord; *pc*, the posterior column of the left side exposed by the removal of the lateral column, and shown ascending to the restiform body as fasciculus cuneatus, *fc*: on the right side the posterior column being removed, *fc*, points to this fasciculus cuneatus cut short below.

B, explanatory outline of the section of the spinal cord. *a*, anterior columns; *p*, posterior; *l*, lateral.

(faisceaux innominés), appearing on the back of the pons Varolii, in the upper part of the floor of the fourth ventricle.

3. The *anterior columns* having reached the apex of the anterior pyramids, are thrust aside from their median position by the decussating fibres derived from the lateral columns, and are then distributed in three divisions. (1,) A very small division, ascends obliquely backwards beneath the olive, and joins the restiform body (Solly). (2,) Another division passes directly upwards, its fibres embracing the olivary nucleus, above which they are again collected together, and are joined by other fibres arising from the nucleus, so as to form the *olivary fasciculus* ; this ascends through the pons and at the side of the cerebral peduncle under the name of the *fillet*, and reaches the corpora quadrigemina and the cerebral hemispheres. (3,) The remaining division of the anterior column ascends into the anterior pyramid, forming its outer part. The anterior pyramids therefore are composed of fibres from the lateral and anterior columns, and are continued up through the pons into the peduncles of the cerebrum.

It is to be remembered, however, that the separation between these different tracts of white fibres cannot be clearly followed out through the whole structure of the medulla oblongata, but that they are more or less blended with one another.

Grey matter of the medulla oblongata followed upwards from the cord.—The central canal of the spinal cord, together with the grey matter which surrounds it, approaches nearer and nearer to the back of the medulla oblongata as it ascends, until it terminates in the calamus scriptorius.

The anterior pyramids are free from grey matter in their interior, and are separated from the rest of the medulla by strong septa of connective tissue, and from one another by a *raphe*, which extends back to the grey matter surrounding the central canal, and which contains mesial horizontal fibres, named *septal*. The posterior cornua of grey matter in the lower part of the medulla oblongata extend transversely outwards from the central canal, and higher up stretch outwards and forwards to the surface. The substantia gelatinosa is swollen out into a mass which appears circular in a transverse section, and is named the *grey tubercle* of Rolando. The anterior cornua, together with the intermedio-lateral tract, which had re-appeared at the upper end of the cord, vanish in the form of elongated radiating streaks ; and between them and the anterior pyramids appear the olivary nuclei, unconnected with the system of grey matter prolonged from the spinal cord. Behind the posterior cornua two new cornua make their appearance—one extending into the processus cuneatus and the other into the posterior pyramid, and both of them increasing in size as the posterior pyramids increase. In the neighbourhood from which these and the posterior cornua spring there is seen in transverse sections a limited bundle of white fibres, the *round fascicle* of Stilling. In the upper part of the medulla oblongata the grey matter is principally spread out on the floor of the fourth ventricle. (Reichert, op. cit., part 2nd, plates I. and II.)

According to the observations of Stilling, part of the grey matter at the back of the medulla forms special deposits or nuclei, which are connected with the roots of the spinal accessory, vagus, glosso-pharyngeal, and hypoglossal nerves. Of these nuclei, the first or lowest is concealed in the substance of the medulla; whilst those which are situated higher up gradually appear in the floor of the fourth ventricle as small angular eminences pointing downwards, near the apex of the calamus scriptorius. The *first nucleus* proceeding from below is that for the spinal accessory nerve. It reaches some way down in the cord, and is there lost in the intermedio-lateral tract. Above this nucleus, and close to the middle of the medulla, is another, the *second*, commencing higher up and connected with the hypoglossal nerve, the roots of which, coming forward between the anterior pyramid and the olivary body, appear at the surface in the depression between those parts. Continuing to ascend, these two nuclei reach the back of the medulla, and then make their appearance in the floor of the fourth ventricle. Higher up, the nucleus for the spinal accessory

nerve is succeeded by a *third* in the same line, which is connected with the nervus vagus, and is also placed to the outer side of that for the hypoglossus. Further out, a *fourth* nucleus begins to be observed, belonging to the glosso-pharyngeal nerve. The last change in the arrangement of these small grey masses consists in the gradual narrowing of the nucleus of the par vagum, and the approximation of those for the hypoglossal and glosso-pharyngeal nerves, which were previously separated by it.

Fig. 352.

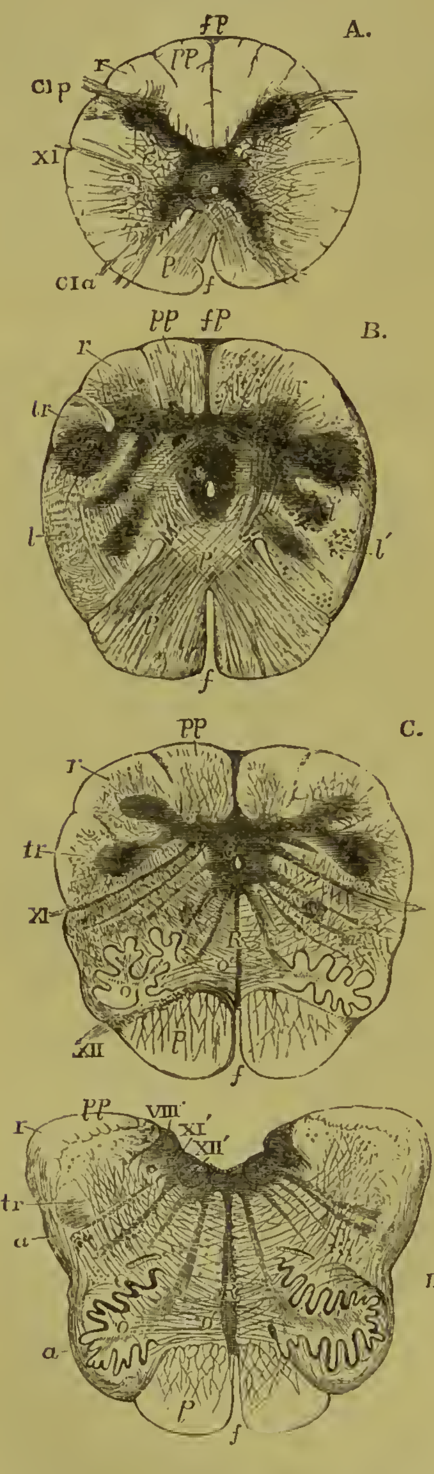


Fig. 352.—Magnified Views of Transverse Sections of the Medulla Oblongata (after Lockhart Clarke, and Reichert). $\frac{2}{1}$

These figures are to be looked upon as in part diagrammatic, no attempt having been made to represent the natural difference of colour in the parts. For the most part, however, the grey substance is indicated by the smoother dark shading, and the white substance by distinct lines.

A, represents a section made at the lower part of the decussation of the pyramids; B, one immediately below the olivary bodies; C, one a very short distance below the calamus scriptorius; and D, a section in the lower part of the fourth ventricle. The references are the following in all the four figures :—

p, anterior pyramids ; *p'*, their decussation ; o, olivary bodies ; *o'*, the radiating fibres proceeding from their interior ; *r*, restiform bodies and their nucleus; *pp*, posterior pyramids ; R, raphe ; *c*, central canal and substance surrounding it ; *tr*, grey tubercle of Rolando ; *f*, anterior median fissure ; *fp*, posterior median fissure ; *a*, arciform fibres ; *l*, lateral column ; *l'*, larger cells and vesicular tract of the lateral column ; CI*a*, anterior roots of the first cervical nerve ; CI*p*, posterior roots ; XII, hypoglossal nerve roots issuing at the side of the pyramid ; XII', its nucleus ; XI, XI', spinal accessory nerve and its nucleus ; VIII', nucleus of the auditory nerve according to Reichert.

In A and B, the decussation of the pyramids is represented ; in A, the anterior and posterior cornua of the grey matter still exist as in the spinal cord ; in B, the anterior cornua are much diminished in size, the posterior have begun to pass outwards, and to be converted into the grey tubercles, and the intermediate nuclei to make their appearance between them ; in C, the central canal is wider and approaches the posterior aspect, and the olivary body appears between the anterior pyramid and the lateral column ; in D, the canal is opened up in the fourth ventricle, and the various grey nuclei are for the most part in the vicinity of its floor.

Langenbeck and Förg maintain that the part regarded by Stilling as the nucleus

for the glosso-pharyngeal nerve is really the place of origin of the greater root of the fifth or trigeminal nerve.

Fig. 353.

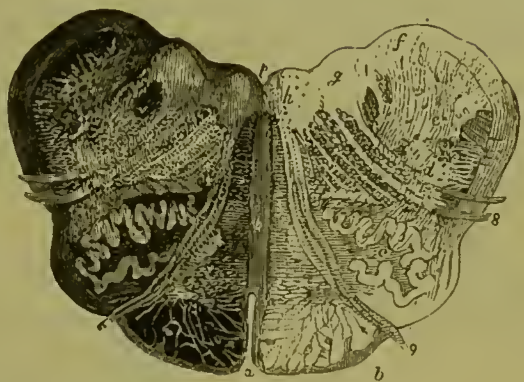


Fig. 353.—Transverse Section of the Medulla Oblongata (after Stilling). $\frac{1}{3}$

The section is made at the level of the middle of the olivary bodies; the effect produced by transmitted light is brought out on the left-hand side of the figure, the half to the right being only sketched. *a*, anterior, and *p*, posterior fissure; *b*, anterior pyramid; *c*, olivary body with its corpus dentatum shown internally; *d*, grey tubercle of Rolando in the lateral column; *e*, the restiform body and its nucleus; *f*, nucleus of the roots of the glosso-pharyngeal nerve; *g*, nucleus of the pneumo-gastric nerve; *h*, that of the hypoglossal nerve; *i*, the septum or raphe; 8, roots of the pneumo-gastric nerve emerging; 9, roots of the hypoglossal nerve.

THE PONS VAROLII AND CEREBELLUM.

The Pons Varolii, or *tuber annulare* (mesocephalon of Chaussier, nodus encephali of Rau and Sömmerring), forms an eminence of transverse fibres above and in front of the medulla oblongata, below and behind the crura cerebri, and between the lateral lobes of the cerebellum. Its margins are arched; the superior much more so than the inferior: thus, at the sides its transverse fibres are much more gathered together, and form at the place where it passes into the cerebellum a narrower bundle, which is named the *middle crus of the cerebellum.* In the middle line the pons presents a shallow groove in which the basilar artery lies, and is perforated by small branches of that artery.

Although the superficial fibres are transverse in their general direction, they are not all parallel to each other. The middle fibres pass directly across, the lower set ascend slightly, whilst the superior fibres, which are the most curved, descend obliquely to reach the crura cerebelli on each side; and there are also one or more superficial bands of the superior fibres which cross obliquely downwards over the middle and lower fibres, and completely conceal them at the sides.

In its *internal structure* the pons consists of the longitudinal or peduncular fibres prolonged upwards from the medulla oblongata, of its own transverse or commissural fibres, through which the longitudinal fibres pass, and of a large intermixture of grey matter. Behind the superficial transverse fibres are seen the prolonged fibres of the anterior pyramids, which, as they ascend through the pons, are widely separated into smaller bundles, intersected by other transverse white fibres, which, with those upon the surface, are all continued into the cerebellum.

The alternation of transverse and longitudinal fibres just described extends to a considerable depth in the pons, the quantity of transverse fibres greatly preponderating; posteriorly there succeeds a third layer, consisting entirely of longitudinal fibres, and comprehending the olivary fasciculi, and the fasciculi teretes.

The *median septum*, or *raphe*, which exists in the medulla oblongata, is

prolonged throughout the whole height of the pons in its back part, but becomes indistinct in approaching the front or basilar surface, except towards its upper and lower edge, where the superficial fibres of the pons are manifestly continuous in the median line with these septal fibres. Bundles of white fibres, belonging to the same system, encircle the crura cerebri at their emergence from the upper border of the pons.

According to Foville, a few fibres from each of the three principal longitudinal elements of the medulla turn forwards and become continuous with the transverse fibres of the pons; and, in like manner, one or more small bundles from each of the crura cerebri take a similar transverse course. (Foville, op. cit., pl. II., figs. 2 and 3; pl. III., figs. 5 and 6).

THE CEREBELLUM, *hinder* or *after brain*, consists of a *body* and of three pairs of *crura* or *peduncles*, by which it is connected with the rest of the encephalon. These crura are named superior, middle, and inferior.

Fig. 354.

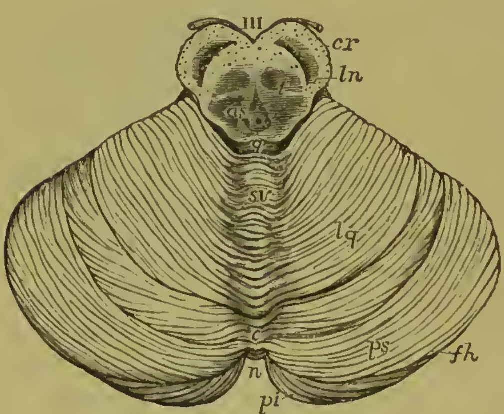


Fig. 354.—OUTLINE OF THE UPPER SURFACE OF THE CEREBELLUM. ½

At the upper part of the figure, the crura cerebri and parts behind them have been cut through and left in connection with the cerebellum.

III, the third pair of nerves lying upon the crura cerebri; *cr*, white matter or crust of the crura cerebri; *ln*, locus niger; *t*, tegmentum containing grey matter in the upper part of the crura; *as*, aqueduct of Sylvius; *q*, corpora quadrigemina, the upper elevations divided; *sv*, superior vermiform process or central folia of the middle lobe of the cerebellum; *lq*, lobulus quadratus; *ps*, posterior superior lobe; *fh*, horizontal fissure; *pi*, posterior inferior lobe; *n*, the notch between the hemispheres.

The *superior peduncles*, crura ad cerebrum or processus ad testes, together with the valve of Vieussens, a lamina stretched between them, connect the cerebellum with the cerebrum.

The *inferior peduncles*, crura ad medullam, are the upper extremities of the restiform bodies.

The *middle peduncles*, or crura ad pontem, much the largest, are the lateral extremities of the transverse fibres of the pons Varolii. They connect together the two halves of the cerebellum inferiorly.

All these peduncles consist of white fibres only; and they pass into the interior of the cerebellum at its fore part.

The cerebellum is covered with grey cortical substance, rather darker than that of the cerebrum. Its greatest diameter is transverse, and extends to about three and a half or four inches: its width from before backwards is about two or two and a half inches; and its greatest depth is about two inches, but it is much thinner round its outer border.

It consists of two lateral *hemispheres* joined together by a median portion called the *vermiform process*, which in the human subject is distinguishable only as a small though well-marked part below, named the *inferior* vermiform process, and a mere elevation above, called the *superior* vermiform process. In birds, and in animals lower in the scale, this middle part of the cerebellum

alone exists ; and in most mammals it forms a central lobe very distinct from the lateral portions.

The hemispheres are separated behind by a deep *notch*. Superiorly, the median portion or upper vermiform process, though slightly elevated, is not marked off from the hemispheres, so that the general surface of the organ, which is here inclined and flattened on either side, is uninterrupted. Below, the hemispheres are convex, and are separated by a deep fossa, named the *vallecula*, which is continuous with the notch behind, and in which the inferior vermiform process lies concealed in a great measure by the surrounding parts. Into this hollow tho medulla oblongata is received in front, and the falx cerebelli behind.

Fig. 355.

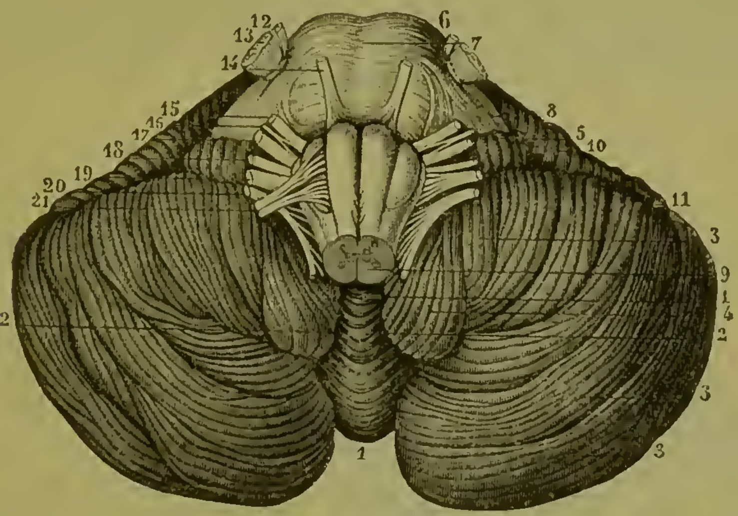


Fig. 355.—Inferior Surface of the Cerebellum with the Pons Varolii and Medulla Oblongata (from Sappey after Hirschfeld and Leveillé). $\frac{2}{3}$

1, placed in the notch between the cerebellar hemispheres, is below the inferior vermiform process ; 2, 2, median depression or vallecula ; 3, 3, 3, the biventral, slender, and posterior inferior lobules of the hemisphere ; 4, the amygdala ; 5, flocculus or subpeduncular lobule ; 6, pons Varolii ; 7, its median groove ; 8, middle peduncle of the cerebellum ; 9, medulla oblongata ; 10, 11, anterior part of the great horizontal fissure ; 12, 13, smaller and greater roots of the fifth pair of nerves ; 14, sixth pair ; 15, facial nerve ; 16, pars intermedia ; 17, auditory nerve ; 18, glosso-pharyngeal ; 19, pneumogastric ; 20, spinal accessory ; 21, hypoglossal nerve.

The cerebellum at the surface and for some depth consists of numerous nearly parallel laminæ or folia, which are composed of grey and white matter, and might be compared with the gyri of the cerebrum, but are smaller and without convolution. These laminæ are separated by slightly-curved grooves or sulci of different depths.

One principal fissure, or sulcus, named the *great horizontal fissure*, divides the cerebellum into an upper and a lower portion. It begins in front at the entrance of the middle peduncles, and passes horizontally backwards round the outer border of the hemispheres. From this primary fissure, numerous others proceed on both the upper and under surface, forming nearly parallel curves, having their concavities turned forwards, and separating the folia from each other. All these furrows do not go entirely round the hemisphere, for many of them coalesce with one another ; and some of the smaller furrows have even an oblique course between the others. Moreover, on opening the

larger fissures, many of the folia are seen to lie concealed within them, and do not reach the surface of the cerebellum.

Certain fissures, which are deeper than the rest, and constant in their position, have been described as separating the cerebellum into lobes, which are named as follows :—

The *central lobe*, situated on the upper surface, consists of about eight folia, immediately adjoining the anterior concave border. The *superior and anterior* lobe, sometimes called *quadrate*, and the *superior and posterior* lobe, are placed between the central lobe and the great horizontal fissure. On the under surface are seen successively the *inferior posterior* lobe, the *slender* lobe, the *biventral* lobe, the *amygdala*, and the *subpeduncular lobe* or *flocculus*. This last-named lobule, *lobule of the pneumo-gastric nerve* (Vicq-d'Azyr), *subpeduncular lobe* (Gordon), or *flocculus*, projects behind and below the middle peduncle of the cerebellum. It is connected by a slender pedicle of white fibres to the rest of the hemisphere ; but its exposed surface is grey, and is subdivided into five or six small laminæ.

Fig. 356.

Fig. 356.—Inferior Surface of the Cerebellum with the Posterior Medullary Velum (after Reil and Reichert and from nature). $\frac{2}{3}$

The medulla oblongata has been in great part removed by a cut passing through it near the pons Varolii ; the two amygdaloid lobules have also been removed, and the medulla and pons Varolii pulled downwards in order to bring into view the posterior medullary velum.

ps, posterior superior lobe of the cerebellum ; *fh*, horizontal fissure ; *pi*, posterior inferior lobe ; *g*, lobulus gracilis ; *bi*, biventral lobe ; *c*, placed on the folia which pass across between the hemispheres of opposite sides ; *p*, pyramid ; *u*, uvula ; *n*, placed in the fourth ventricle immediately below the nodule ; *pv*, on each side, placed on the cut surface where the amygdalæ have been removed, points by a line to the posterior medullary velum ; *v*, *v*, cavity of the fourth ventricle within the borders of the velum and behind the inferior cerebellar peduncles ; the cavity extends on each side into the pedicle of the flocculus, *f*; *m*, section of the medulla oblongata, in which the open condition of the olivary capsules of grey matter is shown ; VI, sixth nerves ; V, fifth nerve-roots, and above them, the facial and auditory roots.

Within the vallecula, or on its borders, the following parts are seen :—

Commencing from behind, a conical and laminated projection, named the *pyramid*, is first met with. In front of that is another smaller projection, called the *uvula*, which is placed between the two rounded lobes at the sides of the vallecula, named the *amygdalæ ;* these terms having been suggested by a comparison with the parts so named in the throat. Between the uvula and amygdalæ on each side, but concealed from view, is extended a ridge

of grey matter indented on the surface, and named the *furrowed band.* Still further forward is the anterior pointed termination of the inferior vermiform process, named the *nodule,* which projects into the fourth ventricle, and has been named the *laminated tubercle* (Malacarne). On each side of the nodule is a thin white lamella of a semilunar form, which is attached by its posterior convex border, and is free and concave in front. The outer ends of these lamellæ are attached to the flocculi, and the inner ends to the nodule, and to each other in front of that projection. The two lamellæ together constitute the *posterior medullary velum,* which has been compared with the valve of Vieussens,—the one being attached to the superior extremity and the other to the inferior extremity of the middle or vermiform portion of the cerebellum. This posterior velum is covered in and concealed by the amygdalæ, and cannot be properly seen until those lobules have been turned aside or removed.

The Fourth Ventricle.—The space left between the medulla oblongata in front and the cerebellum behind, is named the fourth ventricle, or *ventricle of the cerebellum.*

Fig. 357.

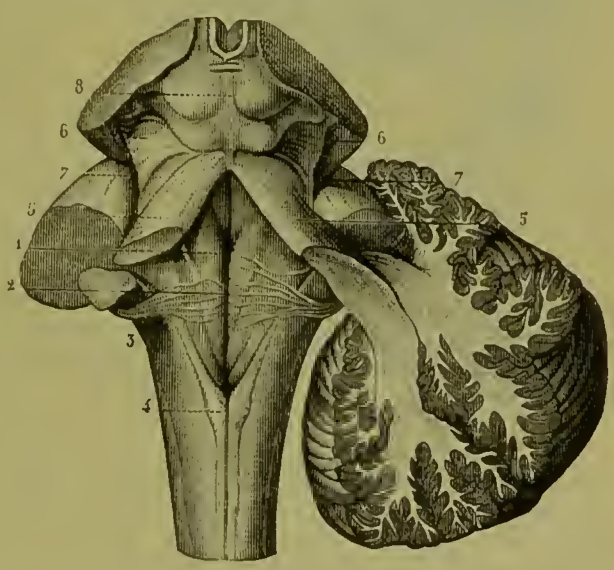


Fig. 357.—View of the Floor of the Fourth Ventricle with the Posterior Surface of the Medulla Oblongata and neighbouring parts (from Sappey after Hirschfeld and Leveillé).

On the left side the three cerebellar peduncles have been cut short; on the right side the white substance of the cerebellum has been preserved in connection with the superior and inferior peduncles, while the middle one has been cut short.

1, median groove of the fourth ventricle with the fasciculi teretes, one on each side; 2, the same groove at the place where the white striæ of the acoustic nerve emerge from it to cross the floor of the ventricle; 3, inferior peduncle or restiform body; 4, posterior pyramid; above this the calamus scriptorius; 5, superior peduncle or processus a cerebello ad cerebrum; on the right side the dissection shows the superior and inferior peduncles crossing each other as they pass into the white stem of the cerebellum; 6, fillet to the side of the crura cerebri; 7, lateral grooves of the crura cerebri; 8, corpora quadrigemina.

The cavity of this ventricle is of a flat rhomboidal shape, being contracted above and below, and widest across its middle part. The anterior extremity of the inferior vermiform process projects into it from behind, and higher up it is covered by the Vieussenian valve. It is bounded laterally by the superior peduncles, and by the line of union of the medulla oblongata and the cerebellum. The upper end of the ventricle is continuous with the Sylvian aqueduct or passage (iter) leading up to the third ventricle.

The anterior surface or *floor* of the fourth ventricle is formed by the back of the medulla oblongata and pons Varolii. It is shaped like a lozenge,

truncated at its upper part. Below, it is bounded by the diverging posterior pyramids and restiform bodies surmounted by the ligula. It has already been sufficiently described in connection with the medulla oblongata.

The *lining membrane* of the ventricle is continuous with that of the ventricles in the interior of the cerebrum, through the aqueduct of Sylvius, in which situation it is marked by delicate rugæ, oblique or longitudinal in direction. At the sides it is reflected from the medulla to the cerebellum, and extends for a considerable distance outwards between the flocculus and the seventh and eighth nerves. At the lower end of the ventricle, there is, as was ascertained by Magendie, a narrow orifice in the membrane by which the cavity communicates with the subarachnoid space.

Projecting into the fourth ventricle at each side, and passing from the point of the inferior vermiform process outwards and upwards to the outer border of the restiform bodies, are two small vascular processes, which have been named the *choroid plexuses* of the fourth ventricle.

Fig. 358.

Fig. 358.—Outline Sketch of a Vertical Section of the Cerebellum to show the Corpus Dentatum in its Medullary Stem. $\frac{2}{3}$

The section has been carried through the left lateral part of the pons so as to divide the superior peduncle and pass nearly through the middle of the left cerebellar hemisphere. The olivary body has also been divided longitudinally so as to expose in section its corpus dentatum.

cr, crus cerebri ; *f*, fillet; *q*, corpora quadrigemina; *sp*, superior peduncle of the cerebellum divided ; *mp*, middle peduncle or lateral part of the pons Varolii, with fibres passing from it into the white stem ; *av*, continuation of the white stem radiating towards the arbor vitæ of the folia ; *cd*, corpus dentatum ; *o*, olivary body with its corpus dentatum ; *p*, anterior pyramid.

Internal structure of the cerebellum.—The central part is composed of white matter which sends out spreading and gradually thinning layers into the interior of all the laminæ, larger and smaller, of the grey substance which form a continuous covering on the surface. In consequence of this arrangement of the white and grey substances, sections of the cerebellum crossing the laminæ, and dividing the grey and white substance together, present a beautifully foliated or arborescent appearance, named *arbor vitæ*. This appearance is seen in any vertical section, but it is most perfect in that which passes through the median plane, where the relative quantity of the central white matter is small. The foliations are arranged somewhat pinnately, the section of each primary lamina having those of secondary laminæ clustered round it like leaflets on a stalk.

In the lateral hemispheres, where the peduncles enter, the white matter is more abundant ; and if a section be made through either hemisphere half way between its centre and the middle of the vermiform process, it will display a nucleus of grey matter, which is named the *corpus dentatum* of the cerebellum. This structure, very similar to that already described in the olivary body of the medulla oblongata, presents the appearance of a waved line of compact yellowish brown matter, surrounded by white substance and containing whitish matter within. This line is interrupted at

its upper and inner part. In whatever direction the section is carried through the corpus dentatum, this waved line is seen, so that the dentate body may be described as consisting of a plicated pouch or capsule of grey substance open at one part and inclosing white matter in its interior, like the corpus dentatum of the olivary body. White fibres may be traced from it to the superior peduncles of the cerebellum and to the valve of Vieussens.

Fig. 359.

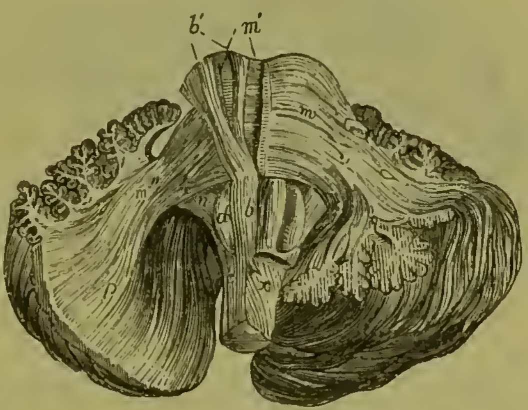


Fig. 359.—View of a Dissection of the Fibres of the Medulla Oblongata and Pons Varolii (from Arnold). $\frac{3}{5}$

b, the anterior pyramid; *b'*, its fibres traced upwards through the pons Varolii; *c*, olivary column; *d*, olivary body; *m*, superficial transverse fibres of the pons on its left side; *m'*, the deeper transverse fibres of the right side; *m''*, the prolongation of these fibres as middle peduncle of the cerebellum; *p*, *q*, their continuation into the laminæ and folia of the cerebellum; *n*, inferior peduncle; *x*, the decussating part of the left lateral column crossing to the right anterior pyramid.

The fibres in the primary lamellæ can be traced continuously from the peduncles of the cerebellum. Upon these central plates are laid other *collateral lamellæ*, which are not connected with the fibres proceeding from the middle of the cerebellum, but merely pass from one folium to another.

The *grey* matter is not uniform throughout its whole thickness, but is composed of two or more layers differing in colour and other characters;—resembling, in this respect, the cortical substance of the posterior convolutions of the cerebrum.

The fibres composing the peduncles of the cerebellum are arranged in its interior in the following manner. The middle peduncles, which are the most superficial, enter the lateral parts of the cerebellum; they may be traced into the folia of those parts, and form a large share of each hemisphere. The inferior peduncles pass upwards into the middle part of the cerebellum, in the folia of which they are distributed, especially in those of the upper surface. The superior peduncles, which are placed nearest to the middle line, are principally connected with the folia of the inferior vermiform process; but a considerable number of them pass into or issue from the grey capsule of the corpus dentatum which has been already described.

A very different account from that which has generally been received of the course and relations of the tracts of nervous substance of the cerebellum has recently been put forward by Luys, and deserves mention in this place. According to the statement of this author, all the fibres of the cerebellar peduncles arise from the interior of the corpora dentata; the cells of those centres receive externally fibres from the laminated periphery of the cerebellum, and internally give origin to the peduncular fibres; the fibres of the inferior peduncles of opposite sides cross the middle line and terminate in the interior of the olivary nuclei; and the fibres of the superior peduncles, likewise decussating in the mesial plane before quitting the cerebellum, terminate in a grey centre in the interior of the tegmentum of the crus cerebri, named by Luys the superior olivary body. He further alleges that different fibres pass in all directions from the superior and inferior olivary bodies, and that thus the fibres of the cerebellum form a separate system indirectly connected with the fibres of the rest of the cerebro-spinal axis. Only a short notice, however, of these views having as yet been published, it will be necessary that the observations on which they are founded be made known and fully corroborated, before statements of so startling a nature can be generally accepted. (Luys, in Journ. de l'Anat. et de Physiol., 1864, p. 225.)

Microscopic Structure.—The cortical grey matter which covers the foliated surface of the cerebellum is made up of the following elements, viz. : 1. Pellucid cells of considerable size. 2. Cells, for the most part of large size, and caudate, having the usual granular contents. These cells are imbedded in a finely-granular matrix ; the greater number of those of the caudate kind have a pyriform shape, and are prolonged

Fig. 360.

Fig. 360.—The Columns of the Medulla Oblongata traced upwards into the Cerebellum and Cerebrum (from Arnold). $\frac{2}{3}$

a, part of the anterior column which ascends in the olivary column ; *b*, decussating portion of the lateral column forming the pyramid and turned down ; *c*, olivary fasciculus ascending deeply through the pons ; *d*, olivary body ; *e*, restiform body ; *f*, *g*, corpora quadrigemina ; *c*, *h*, *i*, the fillet ; *h*, the part which ascends to the cerebral peduncle ; *i*, the part passing up to the corpora quadrigemina ; *m*, *m'*, the transverse fibres of the pons divided ; *n*, inferior peduncle of the cerebellum ; *o*, septal fibres of the medulla oblongata ; *q*, fibres of the inferior peduncle continued into the laminæ of the cerebellum ; *r*, *r*, superior peduncle ; *t*, fasciculus teres ; *u*, thalamus ; *v*, corpus albicans.

Fig. 361.

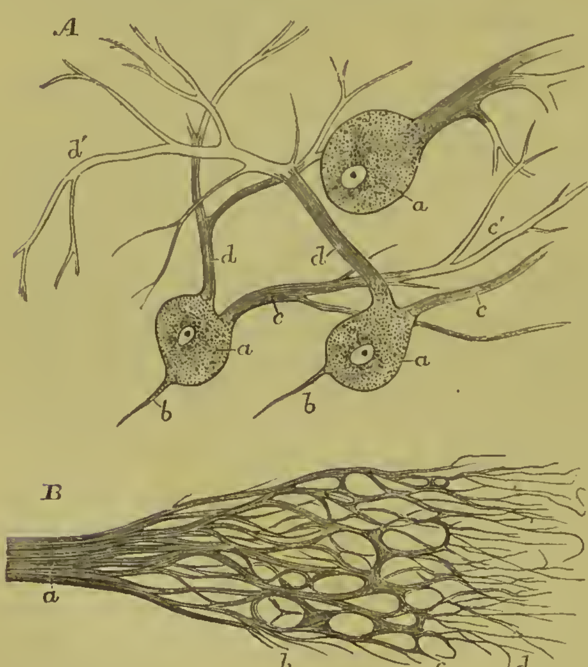


Fig. 361.—Minute Structure of the Substance of the Cerebellum (from Kölliker).

A, large cells from the grey cortical substance of the human cerebellum. $\frac{220}{1}$

a, three large cells exhibiting granular contents and a nucleus ; *b*, the internal processes seen in two of the cells ; *c*, *d*, two external processes running towards the surface from two of the cells, in the third cell one large process only is seen ; *c'*, *d'*, ramified finer parts of these processes.

B, course of the nerve-tubes at the surface of the cerebellum, magnified with a low power.

a, nerve of the medullary substance ; *b*, nervous plexus of the substantia ferruginea ; *c*, border of that substance ; *d*, fine fibres running out from the dark-bordered tubes into the superficial grey substance.

at their small end into a simple or branched appendage, and this process, as first remarked by Purkinje, is in most of them directed towards the surface of the cerebellum. 3. Small bodies like cell-nuclei densely aggregated without any intervening substance. These lie at some depth from the surface ; according to Todd,

they form a thin light-coloured lamina, intermediate between two darker strata of grey matter which contain the nerve-cells; one of these grey strata being the deepest and next the white matter of the cerebellum, while the other, which is the darker coloured of the two, is in contact with the pia mater. 4. Fibres. Tubular nerve-fibres pass from the white into the grey matter, and extend through it nearly as far as the surface. The mode of their termination, which is difficult to trace, has been investigated by various anatomists. According to Valentin, they form loops and return upon their course, but this statement has not been confirmed by other observers.

Gerlach has recently described a very remarkable arrangement of the fibres of the cerebellum. According to him, these fibres, on approaching the grey matter, split up into extremely fine divisions, which form a network, while the granules, which he considers as small cells with ramifying processes, are placed at the angles of the meshes, and branching processes of the large nerve-cells also terminate in the network. According to Kölliker, networks of tubular fibres exist within the grey matter and communicate with the nerve-cells, while the granules belong to the reticulum of connective tissue. Luys, like Gerlach, describes lateral processes as being given off by the nerve-fibres to connect them with the granules, at the same time that they terminate likewise directly, although much attenuated, in the large nerve-cells. (Gerlach, "Microscopische Studien," pl. I., fig. 3; copied in Virchow's "Cellular Pathology," by Chance, p. 269.)

THE CEREBRUM.

The *cerebrum*, or brain proper, constitutes the highest and much the largest portion of the encephalon. It consists of the following parts, viz., the peduncular masses of the crura cerebri and processus a cerebello ad cerebrum; the series of eminences or cerebral centres or ganglia concealed from view, named corpora quadrigemina, optic thalami and corpora striata; the cerebral hemispheres, which are by far the most bulky part of the cerebrum and of the whole encephalon, and form nearly the whole superficial part; various commissural structures including the corpus callosum and fornix; and lastly some smaller structures, viz., the pineal and the pituitary bodies, and the olfactory bulbs.

EXTERIOR OF THE CEREBRUM.

The *cerebral hemispheres* together form an ovoid mass, flattened on its under side, and placed in the cranium with its smaller end forwards, its greatest width being opposite to the parietal eminences. They are separated in the greater part of their extent by the great longitudinal fissure.

Each cerebral hemisphere has an outer or convex surface, which is in contact with the vault of the cranium; an inner or flat surface, of a crescent shape, which forms one side of the longitudinal fissure; and an irregular under surface, which rests on the base of the skull, and on the tentorium cerebelli.

Three lobes, or large divisions, projecting in three different directions, have usually been distinguished in each hemisphere, under the names of anterior, middle, and posterior lobes. The division between the anterior and middle lobes is very clearly defined below and on the sides by a deep cleft, named the Sylvian fissure. There is no similar demarcation between the middle and posterior lobes; but anatomists have generally considered as the posterior lobe that part of the hemisphere which lies over the cerebellum. The under surface of the anterior lobe is triangular and excavated to adapt it to the roof of the orbit on which it rests. The middle lobe is rounded

and prominent, and occupies the middle fossa of the skull—the edge of the lesser wing of the sphenoid bone corresponding with the Sylvian fissure.

Fig. 362.

Fig. 362.—Upper Surface of the Brain showing the Convolutions (from R. Wagner). $\frac{1}{2}$

This view was taken from the brain of a famous mathematician, Professor C. F. Gauss, who died in 1854, aged 78. It is selected as an example of a well-formed brain of the usual size with fully developed convolutions.

a, superior or first frontal convolution ; *a′*, second or middle frontal ; *a″*, third or inferior frontal ; A, A, anterior ascending parietal convolution ; B, B, posterior ascending parietal convolution ; *b*, first or upper parietal convolution ; *b′*, second or middle ; *b″*, third or inferior ; *c*, first or upper temporal convolution ; *d*, first or upper occipital convolution ; *d′*, second or middle ; *d″*, third or lower ; *l*, *l*, the superior longitudinal fissure ; *r*, the fissure of Rolando ; *p*, the external perpendicular fissure.

The posterior lobe is smooth and slightly concave on its under surface, where it rests on the arch of the tentorium.

It is right to remark that some anatomical writers have admitted only *two* lobes, reckoning the middle and posterior lobes as one, under the name of the posterior lobe; while others more recently have divided the middle lobe into two, an upper and lower, and have added that of the island of Reil, so as to make five principal lobes in all. These have been named respectively the frontal, parietal, temporal, occipital, and central lobes.

The *great longitudinal fissure*, seen upon the upper surface of the brain, extends from before backwards throughout its whole length in the median plane, and thus separates the cerebrum, as already stated, into a right and left hemisphere. On opening this fissure, it is seen, both before and behind, to pass quite through to the base of the cerebrum : but in the middle it is interrupted by a large transverse mass of white substance, named the *corpus callosum*, which connects the two hemispheres together. While the brain is in its natural situation, this fissure is occupied by a vertical process of the dura mater—the falx cerebri,—which dips down between the two hemispheres, not quite reaching to the corpus callosum.

The *Sylvian fissure*, which separates the anterior and middle lobes, passes at first upwards and backwards in the outer part of the hemisphere, and

divides into two branches, anterior and posterior. It lodges the trunk and primary divisions of the middle cerebral artery, and at its commencement presents a spot pierced by numerous small arterial branches, and thence named the *locus perforatus anticus.*

The surface of the hemispheres is composed of grey matter, and is moulded into numerous smooth and tortuous eminences, named *convolutions*, or *gyri*, which are marked off from each other by deep furrows, called *sulci*, or *anfractuosities.*

Fig. 363.

Fig. 363.—Lateral View of the Right Cerebral Hemisphere (from Sappey after Foville). ½

1, fissure of Rolando ; 2, anterior ascending parietal convolution ; 3, frontal convolutions connected posteriorly with the anterior ascending parietal ; 4, union of two frontal convolutions ; 5, posterior ascending parietal convolution ; 6, another parietal convolution similarly connected with those on the inner surface ; 7, 7, anterior part of the convolution of the fissure of Sylvius ; 8, 8, horizontal part of the same convolution ; 9, 9, posterior part ; 10, 11, 12, anterior, middle, and posterior principal convolutions of the island of Reil or central lobe ; 13, supraorbital convolution ; 14, part of the temporal lobe ; 15, occipital lobe.

Cerebral Convolutions.—The convolutions are covered closely throughout by the vascular investing membrane, the pia mater, which sends processes down to the bottom of the sulci between them, while the serous covering, the arachnoid membrane, passes from one convolution to another, over their summits and without dipping between them. The sulci are generally from half an inch to an inch in depth ; but in this respect there is much variety in different brains, and in different parts of the same brain ; those upon the outer convex surface of the hemisphere being the deepest. In general, the depth of a convolution exceeds its thickness ; and its thickness, near the summit, is somewhat greater than through its base.

Since the external grey or cortical substance is continuous over the whole surface of the cerebral hemispheres, being found alike within the sulci and upon the gyri, a far greater extent of grey matter is thus exposed to the vascular surface of the pia mater with a given size of the brain than could have been the case had the hemispheres been plain and destitute of convolutions.

The general arrangement of the convolutions has been made the subject

of study by various anatomists in earlier and recent times, but still requires farther elucidation. An attempt to describe minutely all the individual gyri would be difficult and useless, owing to their irregularity in different cases, and their want of symmetry in the same brain. Nevertheless, there are some sufficiently constant in presence, and characteristic in situation and form, to admit of being specially described ; and it seems probable that by a sufficiently careful comparison of the convolutions in different animals, and the observation of their development in the fœtus, certain general facts may be ascertained regarding them, tending to throw light upon their disposition in man.

Fig. 364.

Fig. 364.—Outline of the Cerebrum as seen from the left side, showing the Convolutions as distinguished by Gratiolet. $\frac{1}{2}$

F, frontal lobe ; P, parietal lobe ; T, temporal lobe ; O, occipital lobe ; R, R, fissure of Rolando ; *s*, *s*, fissure of Sylvius, posterior division ; *s'*, *s'*, its anterior division ; C, at the junction of the two, marks the place of the central lobe or convolutions of the island of Reil ; *p*, the place of the vertical or occipital fissure ; *a*, *a'*, *a''*, superior, middle and inferior frontal convolutions ; *a**, supra-orbital convolutions ; A, anterior transverse or ascending parietal convolution ; B, posterior transverse or ascending parietal convolution ; *b*, *b'*, *b*,'' upper, middle and lower parietal convolutions ; c, *c'*, *c''*, upper, middle and lower temporal convolutions ; *d*, *d'*, *d''*, upper, middle and lower occipital convolutions ; between *b*, *b'*, *b''*, and *d*, *d'*, *d''*, are seen the connecting convolutions ; between c and *c'*, the parallel fissure.

The *Island of Reil* constitutes the set of convolutions (*gyri operti*) which appear earliest both in the fœtus and in the animal series. It is a triangular eminence, broken externally into short radiating convolutions, which forms a delta between the anterior and posterior division of the fissure of Sylvius, and is limited externally by a deep sulcus. This mass, constituting the central lobe of recent authors, derives additional interest from being the centre round which the principal convolutions of the cerebrum are arranged. It is only brought into view by laying open the fissure of Sylvius. (See Figs. 365, 369, and 379.)

The *convolution of the Sylvian fissure* is a very large convolution, which is also early in its appearance in animals. Commencing in front of the inner end of the Sylvian fissure, it takes a tortuous and much folded course all round that fissure, giving off numerous secondary gyri, and terminates behind the fissure opposite the point where it began.

The *gyrus fornicatus*, *convolution of the corpus callosum*, or *internal con-*

volution, is one of the most distinct and symmetrical convolutions in the whole brain. Commencing on the under surface of the brain, immediately before the anterior perforated space, it ascends a short distance in front of the anterior recurved extremity of the corpus callosum, and then runs backwards immediately above that body, as far as its posterior extremity : there it turns downwards and forwards, embracing the cerebral peduncle, to reach the entrance of the Sylvian fissure. This long convolution, therefore, describes a sort of arch or ring, open or interrupted opposite the Sylvian fissure, and embracing the corpus callosum above, and the cerebral peduncle below. It thus, as was pointed out by Foville, forms a sort of rim or border to the grey matter, whence it is named by him *convolution d'ourlet.* The surface of this convolution, especially towards its inferior termination, is covered by a very thin cribriform layer of white substance, which, with the grey matter beneath, gives the surface a mottled aspect. This has been called the *reticulated white substance.*

The *marginal convolution of the longitudinal fissure* is a large convolution which may be traced, more or less indented or interrupted however in its course, along the line of junction between the convex and flat surfaces of the hemisphere, forming the lip of the great longitudinal fissure. It commences on the under surface of the brain, in common with the gyrus fornicatus, and passing forwards, forms the inner border of the triangular orbital surface of the anterior lobe. In this part it is cleft longitudinally by a deep sulcus, into which the olfactory bulb is received, and which, it may be mentioned, is developed at an earlier period than the convolution itself. On the front and upper surface of the cerebrum, this convolution may generally be traced for some distance along the margin of the longitudinal fissure, but soon becomes marked by deep sulci ; and, thus interrupted, may be followed round the posterior extremity, and along the under surface of the hemisphere forwards as far as the point of the middle lobe, running parallel for some space with the under portion of the gyrus fornicatus. Two of the sulci which interrupt the marginal convolution are very constant, viz., the vertical fissure with the fissure of the hippocampi, and the fissure of Rolando.

The *fissure of the hippocampi* has a deep origin in the inner margin of the middle lobe of the brain between the fascia dentata and the gyrus fornicatus, and passing backwards crosses that gyrus on the under surface of the brain, behind the corpus callosum, and proceeds in a nearly horizontal course along the inner face of the hemisphere. This fissure is important as forming the reverse of the elevations of the hippocampi in the interior of the brain, and as being (according to Reichert) produced at an early period in connection with the general development of the hemispheres, and being comparable therefore rather to the fissure of Sylvius than to a mere sulcus. The part of the gyrus fornicatus beneath this fissure is distinguished as the *gyrus hippocampi.*

The *fissure of Rolando* starting from behind the vertex runs outwards and forwards from the longitudinal fissure, so that the right and left grooves form a V-shaped line open in front. It derives its importance from being characteristic of the form of the brain of man and the quadrumana, and separating two considerable convolutions, which extend from the superior longitudinal fissure to the fissure of Sylvius. These convolutions, peculiar to the greater number of Simiæ and attaining their fullest development in man, constitute the anterior and posterior *transverse* or anterior and posterior *ascending parietal* convolutions.

The *vertical fissure* of recent authors crosses the marginal convolution in the posterior part of the cerebrum, extending slightly outwards upon its upper surface and more deeply on its internal aspect, so as to form a separation between the so-called parietal and occipital lobes.

According to Foville the convolutions may be arranged in four principal orders, founded in a great measure on their relative connections with the anterior perforated space, which, in his estimation, is a part of the highest importance.

The *first* order issues from the perforated space, and consists of two portions. One, large and vertical, is the gyrus fornicatus, without its ascending secondary gyri; the other, short and horizontal, is the slightly-elevated ridge which bounds the perforated space in front and on the outer side.

Fig. 365.

Fig. 365.—Right half of the Brain divided by a Vertical Antero-Posterior Section (from various sources and from nature). ½

1, great superior or marginal convolution; 2, convolution of the corpus callosum; 3, secondary convolutions running between this and the preceding; within the numbers 2, 2, 2, the corpus callosum; 4, the fifth ventricle; 5, the third ventricle (see Fig. 377 for a larger view of these parts); 5′, pituitary body; 6, immediately behind the corpora quadrigemina and pineal gland; +, the fourth ventricle; 7, pons Varolii; 8, medulla oblongata; 9, cerebellum; the middle lobe showing the section of the arbor vitæ; I, the olfactory bulb; II, the right optic nerve; the commissure cut through; III, the right nerve of the third pair.

The *second* order, also consisting of two portions, commences from the horizontal portion of the first order on the limits of the perforated space. One part corresponds with the marginal convolution of the longitudinal fissure, as already described, except that part of it on the orbital surface of the anterior lobe which lies to the outer side of the olfactory sulcus; the other part is the convolution of the Sylvian fissure.

The *third* order consists of two sets, of which one occupies the inner surface of the hemisphere, and connects the gyrus fornicatus in its whole length with the marginal convolution of the longitudinal fissure; the other set lies in the Sylvian fissure, forms the island of Reil, and connects the short horizontal portion of the first order with the convolution surrounding that fissure.

The convolutions of the *fourth* order, the largest, deepest, and least symmetrical of all, are quite detached from the perforated space, and have no relation to the first order of convolutions. They connect the two convolutions of the second order

together, viz., the marginal convolution of the median fissure and that of the Sylvian fissure, and occupy the outer or convex surface of the cerebral hemisphere.

Leuret, by an extended comparison of the brains of different animals, was led to divide mammals into fourteen groups, according to the disposition of the convolutions. In the lowest or simplest group, including the bat, mole, and rat, the *Sylvian fissure* is the only division of the surface present, or along with it a few very slight sulci. In a higher group, containing the fox and dog, and presenting in a marked form the typical mode of division, Leuret recognises as *fundamental* six convolutions —four external, including the superior marginal and that of the fissure of Sylvius, and two internal, viz., the supraorbital and gyrus fornicatus. In other groups, together with various other modifications of form by subdivision or by union through supplemental ones, the number of the fundamental convolutions is frequently reduced to five or to four.

In the brain of the elephant, on the other hand, placed by Leuret in the thirteenth group, he recognises the *superior transverse* convolutions; and in the last group, comprehending the quadrumana, these transverse convolutions are two in number, and are separated by the groove, named by Leuret fissure of Rolando. These transverse or ascending parietal convolutions are a constant and well-marked feature of the human brain, in which they attain their highest development.

Fig. 366.

Fig. 366.—Outline of the Inner Surface of the Right Half of the Brain, showing the Principal Lobes and Convolutions according to Gratiolet.

F, frontal lobe; P, parietal; O, occipital; T, temporal; *r*, fissure of Rolando; *f*, fronto-parietal fissure; *p'*, inner perpendicular or occipito-parietal fissure; *h*, the calcarine fissure of Huxley, and with the line continued forwards between *g* and *h'*, the hippocampal fissure; *h'*, convolution of the hippocampus; *g*, gyrus fornicatus or convolution of the corpus callosum; *s*, Sylvian fissure; I, olfactory bulb; II, optic nerve; III, third nerve; C, cerebellum.

More recently, Gratiolet has arranged the convolutions with great detail, according to their most distinguishing common features in man and the simiæ. On the external surface of the hemisphere he distinguishes five lobes, viz., the *frontal* and *parietal* above the fissure of Sylvius; the *temporo-sphenoidal* below that fissure; the *occipital* behind it, and the island of Reil, or *central lobe*, within the fissure. The frontal lobe he divides into an orbital and frontal portion, and in the frontal portion

distinguishes a *superior, middle,* and *inferior tier* of convolutions. In the parietal lobe are the *anterior* and *posterior ascending convolutions* (convolution of Rolando) surrounding the fissure of Rolando, and behind these a *curved lobe.* In the temporo-sphenoidal lobe are described a *superior, middle,* and *inferior convolution,* lying parallel to the fissure of Sylvius. The occipital lobe presents also *three tiers,* but less distinct than those of the frontal, and besides these are four convolutions uniting the occipital and parietal lobes, named by Gratiolet *plis de passage,* or the connecting convolutions.

The internal surface of the hemisphere Gratiolet divides into the *fronto-parietal lobe,* corresponding in extent to the frontal and parietal lobes of the external surface, and limited behind by the *internal perpendicular fissure,* the *occipital lobe* between that fissure and the fissure of the hippocampi; and the *occipito-temporal* lobe, including the tentorial surface, and extending outwards to the sphenoido-temporal lobe.

It is to be remarked, however, that the divisions and nomenclature of Gratiolet, however useful they may be for the purpose of explicit comparison of the convolutions of the human brain with those of the quadrumana, the study in which the inventor has made use of them, are yet of a somewhat artificial description, and may not be applicable to a more extended comparison of the disposition of the convolutions among animals.

From Reichert's plates it is apparent that the internal perpendicular fissure (occipito-parietal of Huxley) is the upper of two branches into which the fissure of the hippocampi divides posteriorly in its first development, and which together with that fissure constitutes his *fissura occipitalis.* The inferior branch, the posterior part of the fissure of the hippocampi, is the *calcarine fissure* of Huxley.

Not only the comparison of the brain of man with those of other animals, but likewise the comparison of human brains one with another establishes the existence of a relation between mental development and the complication, size, and depth of the cerebral convolutions, and the extent of the grey matter contained in them.

On the subject of the cerebral convolutions the reader may consult, in addition to the works of Arnold, Tiedemann, Foville and Reichert, that of Leuret and Gratiolet, "Anat. Comp. du Système Nerveux, 1839-57." Gratiolet, "Mém. sur les Plis Cérébraux de l'Homme et des Primates, 1854." R. Wagner, "Uber die typischen Verschiedenh. der Windungen der Hemisphären," &c., Gotting. 1860-62. Huschke, "Schädel, Hirn und Seele," 1854; Huxley, "Brain of Ateles paniscus," Proc. of Zool. Soc., June, 1861; J. Marshall, "On the Brain of a Bush-woman, and on the Brains of two Idiots, &c.," Trans. Roy. Soc. 1863.

Base of the Cerebrum.—When the brain is turned with its base uppermost, and the parts of which it is composed are allowed to fall slightly asunder by their own weight, two considerable masses, consisting of white substance externally, are seen emerging together from the fore part of the pons Varolii, and, separating from each other as they proceed forwards and outwards, to enter the inner and under part of the right and left cerebral hemispheres. These white masses, which are marked on the surface with longitudinal striæ, and have somewhat the appearance of large bundles of fibres, are the *peduncles* or crura of the cerebrum. Immediately before entering the corresponding hemisphere, each is crossed by a flattened white cord, named the *optic tract,* which, adhering by its upper border to the peduncle, is directed forwards and inwards, and meets in front with its fellow of the opposite side to form the optic commissure, from the fore part of which the optic nerves proceed.

Limited behind by these diverging peduncles, and in front by the converging optic tracts, is a lozenge-shaped interval, called the *interpeduncular space,* in which are found, in series from behind forwards, the posterior perforated space, the corpora albicantia, and the tuber cinereum, from which is prolonged the infundibulum attached to the pituitary body.

The *posterior perforated space* (locus perforatus posterior) is a deep fossa

situated between the peduncles, the bottom of which is composed of greyish matter, connecting the diverging crura together, and named pons Tarini. It is perforated by numerous small openings for the passage of blood-vessels; and some horizontal white striæ usually pass out of the grey matter and turn round the peduncles immediately above the pons.

Fig. 367.

Fig. 367.—Base of the Brain with the Origins of the Cerebral Nerves. ½

This figure is taken from an adult male brain which had been hardened in alcohol. 1, superior longitudinal fissure; 2, fissure of the olfactory tract and lower part of the superior convolution; 2′, orbital convolutions; 2″, external or inferior frontal convolution; 3, inner part of the fissure of Sylvius, near the anterior perforated spot; 3, 3, outer part; 4, inner convolution of the temporal lobe; 4′, middle convolution; 4″, outer convolution; 5, 5′, occipital lobe; 6, on the right pyramidal body of the medulla oblongata above the decussation; 7, amygdaloid lobe of the cerebellum; 8, biventral lobe; 9, lobulus gracilis; 10, posterior inferior lobe; +, the inferior vermiform process; I, olfactory bulb; I′, the tract divided on the left side, showing the three white striæ by which it is connected with the brain; II, in the anterior perforated spot, marks the right optic nerve; the left has been cut short; III, on the right crus cerebri, denotes the third pair; IV, on the inner convolution of the middle lobe, the fourth pair; V, the trigeminus; VI, on the pons Varolii, the sixth; VII, also on the pons Varolii, the seventh; VIII, on the left lobe of the cerebellum below the horizontal fissure and the flocculus, denotes the eighth pair; IX, on the upper part of the right amygdaloid lobe, denotes the ninth pair; X, on the same, the suboccipital nerve.

The *corpora albicantia* or mammillaria are two round white eminences in front of this fossa, each about the size of a small pea, surrounded by grey matter, and connected together across the middle line.

The corpora albicantia are formed, as will hereafter be explained, by the anterior extremities of the fornix; hence they have also been named *bulbs of the fornix*. In

the fœtus they are at first blended together, and they become separated about the beginning of the seventh month. In most vertebrate animals there is but one white eminence or corpus albicans in their place.

Fig. 368.

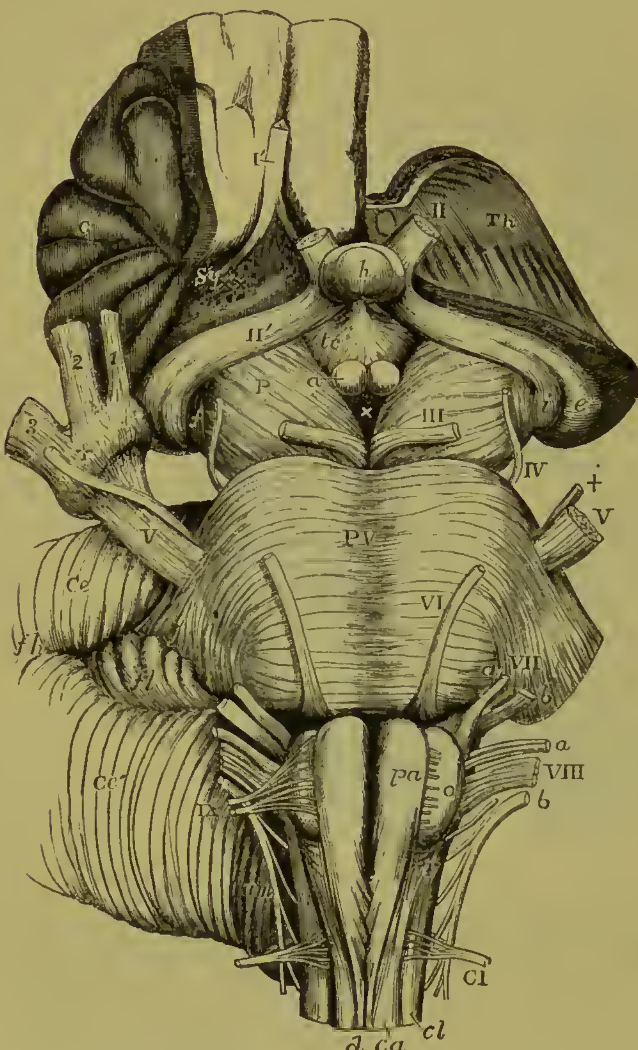


Fig. 368.—View from before of the Medulla Oblongata, Pons Varolii, Crura Cerebri, and other Central Portions of the Encephalon.

On the right side the convolutions of the central lobe or island of Reil have been left, together with a small part of the anterior cerebral convolutions: on the left side these have been removed by an incision carried between the thalamus opticus and the cerebral hemisphere.

I′, the olfactory tract cut short and lying in its groove between two convolutions; II, the left optic nerve in front of the commissure; II′, the right optic tract; *Th*, the cut surface of the left thalamus opticus; C, the central lobe or island of Reil; *Sy*, fissure of Sylvius; × ×, locus perforatus anterior; *e*, the external, and *i*, the internal corpus geniculatum; *h*, the hypophysis cerebri or pituitary body; *tc*, tuber cinereum with the infundibulum; *a*, one of the corpora albicantia; P, the cerebral peduncle or crus; *f*, the fillet; III, close to the left oculo-motor nerve; ×, the locus perforatus posticus; PV, pons Varolii; V, the greater root of the fifth nerve; +, the lesser or motor root; on the right side this + is placed on the Gasserian ganglion, and points to the lesser root, where it proceeds to join the inferior maxillary nerve; 1, ophthalmic division of the fifth nerve; 2, superior maxillary division; 3, inferior maxillary division; VI, the sixth nerve; VII *a*, the facial; VII *b*, the auditory nerve; VIII, the pneumo-gastric nerve; VIII *a*, the glosso-pharyngeal; VIII *b*, the spinal accessory nerve; IX, the hypoglossal nerve; *fl*, the flocculus; *fh*, the horizontal fissure of the cerebellum (*Ce*); *am*, the amygdala; *pa*, the anterior pyramid; *o*, the olivary body; *r*, the restiform body; *d*, the anterior median fissure of the spinal cord, above which the decussation of the pyramids is represented; *ca*, the anterior column; *cl*, the lateral column of the spinal cord; CI, the suboccipital or first cervical nerve.

The *tuber cinereum* is a lamina of grey matter extending forwards from the corpora albicantia to the optic commissure, to which it is attached, and forming, as afterwards described, part of the floor of the third ventricle,

In the middle it is prolonged into a hollow conical process, the infundibulum, to the extremity of which is fixed the pituitary body.

The *pituitary body* or *hypophysis cerebri*, formerly called pituitary gland, from its being erroneously supposed to discharge *pituita* into the nostrils, is a small reddish grey mass, of a somewhat flattened oval shape, widest in the transverse direction, and occupying the sella turcica of the sphenoid bone. It consists of two lobes, of which the anterior is larger, and concave behind, where it embraces the smaller posterior lobe. Its weight is from five to ten grains. In the adult it is solid, and of a firm consistence.

The anterior lobe consists of two kinds of matter, one hard and grey, the other, situated within, softer and of a yellowish white colour. The posterior lobe is darker and redder than the anterior. Both are very vascular.

The pituitary body appears to approach in structure to the vascular or ductless glands, such as the thyroid and suprarenal bodies, &c. According to Sharpey's observations, with which those of subsequent writers agree, it differs greatly in structure, at least in its anterior and larger lobe, from any other part of the encephalon. The substance of the anterior lobe appears to be constituted by a membranous tissue forming little round cavities or loculi, which are packed full of nucleated cells. The loculi are formed of transparent, simple membrane, with a few fibres and corpuscles resembling elongated cell-nuclei disposed round their walls. The cells contained in the cavities are of various sizes and shapes, and not unlike nerve-cells or ganglion globules; they are collected into round clusters, filling the cavities, and are mixed with a semi-fluid granular substance. This thin granular matter, together with the cells and little specks of a clear glairy substance like mucus, can be squeezed from the cut surface, in the form of a thick, white, cream-like fluid.

In the fœtus, the pituitary body is proportionally large, and contains a cavity which communicates, through that of the infundibulum, with the third ventricle. This body is constantly present, and has the same connection with the brain in all vertebrate animals.

In the middle line of the base of the brain, in front of the optic commissure, is the anterior portion of the great longitudinal fissure, which passes down between the hemispheres. At a short distance in front of the commissure, this fissure is crossed transversely by a white mass, which is the anterior recurved extremity of the corpus callosum. On gently turning back the optic commissure, a thin connecting layer of grey substance, the *lamina cinerea*, is seen occupying the space between the corpus callosum and the commissure, and continuous above the commissure with the tuber cinereum. It is connected at the sides with the grey substance of the anterior perforated space, and forms part of the anterior boundary of the third ventricle : it is somewhat liable to be torn in removing the brain from the skull ; and in that case, an aperture would be made into the fore part of the third ventricle.

At a short distance outwards from the lamina cinerea is the *anterior perforated spot* (locus perforatus anticus), a depression near the entrance of the Sylvian fissure, floored with grey matter, and pierced with a multitude of small holes for the passage of blood-vessels, most of which are destined for the corpus striatum,—the deeper portion of the brain beneath which it lies.

The grey surface of each perforated space is crossed by a broad white band, which may be traced from the middle of the under surface of the corpus callosum in front, backwards and outwards along the side of the lamina cinerea towards the entrance of the Sylvian fissure. These bands of the two sides are named the *peduncles of the corpus callosum*.

When the entire encephalon is viewed from below, the back part of the

under surface of the cerebrum is concealed by the cerebellum and the pons Varolii. If, however, these parts be removed, it will be seen that the two hemispheres of the cerebrum are separated behind as they are in front, by the descent of the great longitudinal fissure between them, and that this fissure is arrested by a cross mass of white substance, forming the posterior extremity of the corpus callosum. This posterior part of the great longitudinal fissure is longer than the anterior portion.

INTERNAL PARTS OF THE CEREBRUM.

The anatomy of the interior of the cerebrum is most conveniently studied by removing, after the manner of Vieussens and Vicq-d'Azyr, successive portions of the hemispheres by horizontal sections, beginning from above.

Fig. 369.

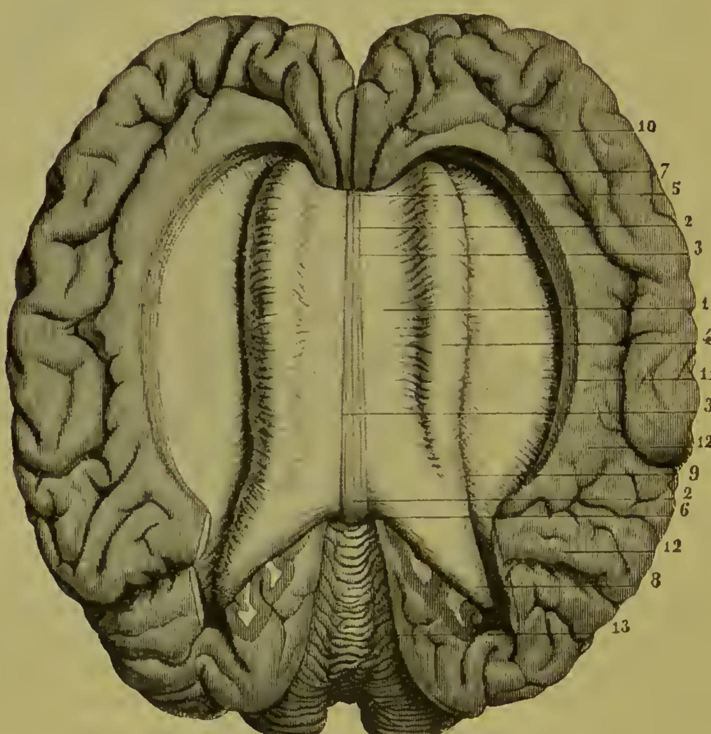


Fig. 369.—View of the Corpus Callosum from above (from Sappey after Foville). ½

The upper surface of the corpus callosum has been fully exposed by separating the cerebral hemispheres and throwing them to the side ; the gyrus fornicatus has been detached, and the transverse fibres of the corpus callosum traced for some distance into the cerebral medullary substance.

1, the upper surface of the corpus callosum ; 2, median furrow or raphe ; 3, longitudinal striæ bounding the furrow ; 4, swelling formed by the transverse bands as they pass into the cerebrum ; 5, anterior extremity or knee of the corpus callosum ; 6, posterior extremity ; 7, anterior, and 8, posterior part of the mass of fibres proceeding from the corpus callosum ; 9, margin of the swelling ; 10, anterior part of the convolution of the corpus callosum ; 11, hem or band of union of this convolution ; 12, internal convolutions of the parietal lobe ; 13, upper surface of the cerebellum.

The first horizontal section, to be made about half an inch above the corpus callosum, displays the internal white matter of each hemisphere, speckled with red spots where its blood-vessels have been divided, and sur-

rounded on all sides by the grey matter which is seen to follow closely the convoluted surface, and to be of nearly equal thickness at all points. This white central mass in each hemisphere was named by Vicq-d'Azyr *centrum ovale minus.* On separating the remaining portions of the two hemispheres from each other, two sulci are seen to exist between the corpus callosum and the gyri immediately in contact with it, viz., the gyrus fornicatus of each side. These sulci were distinguished by the older anatomists as *ventricles of the corpus callosum.*

Another section being made at the level of the corpus callosum, the white substance of that part is seen to be continuous with the internal medullary matter of both hemispheres: and the large white medullary mass thus displayed, surrounded by the border of cortical substance, constitutes what is generally described as the *centrum ovale* of Vieussens.

The *corpus callosum* or *great commissure* (trabs cerebri) is a white structure, with a length not quite half of that of the brain, and approaching about two-fifths nearer to the front than the back of the hemispheres. It

Fig. 370.

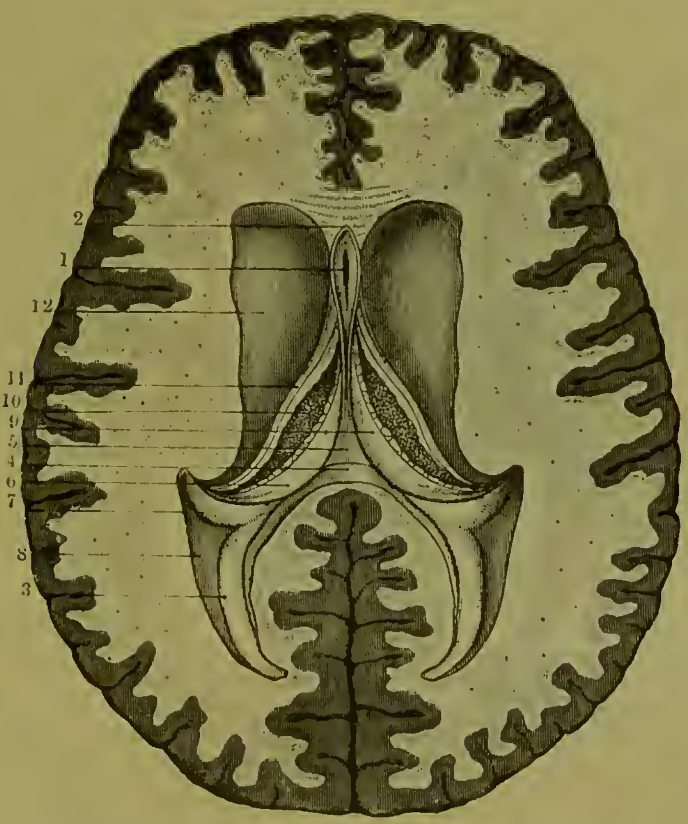


Fig. 370.—Horizontal Section of the Brain showing the Lateral Ventricles and the Fifth Ventricle opened (from Sappey after Vicq-d'Azyr). ½

1, the fifth ventricle; 2, the two laminæ of the septum lucidum meeting in front of it; 3, lesser hippocampus of the posterior cornu; 4, horizontal section of the posterior swelling of the corpus callosum; 5, middle part of the fornix, where it has been separated from the corpus callosum; 6, posterior pillar of the fornix; 7, hippocampus major descending in the middle cornu; 8, eminentia collateralis; 9, lateral parts of the fornix; 10, choroid plexus; 11, tænia semicircularis; 12, corpus striatum.

is about an inch in width behind, and somewhat narrower in front. Its thickness is greater at the ends than in the middle, and is greatest behind,

where it is nearly half an inch. It is arched from before backwards. Its upper surface is distinctly marked by transverse furrows, which indicate the direction of the greater number of its fibres. It is also marked in the middle by a slight longitudinal groove, the *raphe*, which is bounded laterally by two white tracts, placed close to each other, named *striæ longitudinales*, or *nerves of Lancisi.* On each side, near the margin, are seen other longitudinal lines (striæ longitudinales laterales) occasioned by a few scanty white fibres.

In front, the corpus callosum is reflected downwards and backwards, between the anterior lobes, forming a bend named the *genu.* The inferior or reflected portion, which is named the *rostrum*, becomes gradually narrower as it descends, and is connected by means of the lamina cinerea with the optic commissure. It also gives off the two bands of white substance, already noticed as the *peduncles* of the corpus callosum, which, diverging from one another, run backwards across the anterior perforated space on each side to the entrance of the Sylvian fissure.

Fig. 371.

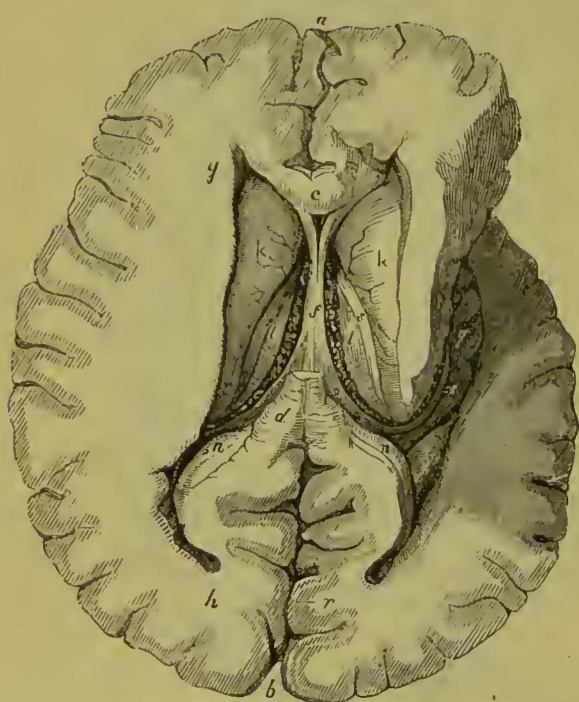


Fig. 371.—The Lateral Ventricles opened by a Horizontal Section, and the Middle Cornu exposed on the right side. ½

a, *b*, anterior and posterior parts of the great longitudinal fissure ; *c*, section of the anterior part of the corpus callosum ; *d*, posterior part of the same ; *e*, the left choroid plexus ; *f*, the fornix ; *g*, the anterior, *h*, the posterior, and *q*, the descending cornu of the lateral ventricle ; *k*, *k*, corpora striata ; *l*, *l*, optic thalami ; *n*, *n*, right and left hippocampus minor ; *o*, posterior pillar of the fornix ; *v*, the corpus fimbriatum into which it passes ; *q*, cornu ammonis or pes hippocampi ; *h*, the medullary substance of the cerebral hemisphere ; *r*, part of the cortical substance showing alternate grey and white matter ; *s*, *s*, tænia semicircularis ; *y*, eminentia collateralis.

Behind, the corpus callosum terminates in a free thickened border (*bourrelet*, pad), the under surface of which is also free for a short distance forwards.

The under surface of the corpus callosum is connected behind with the fornix, a structure to be presently described, and in the rest of its length with the septum lucidum, a vertical partition between the two lateral ventricles.

Although it presents a few longitudinal white fibres on its surface, the corpus callosum consists almost entirely of fibres having a transverse course towards each side, and spreading in a radiating manner into the substance of the two hemispheres. As the transverse fibres from the anterior and posterior lobes of the cerebrum are necessarily aggregated in large numbers near the corresponding ends of the corpus callosum, its greater thickness at those points, in comparison with the rest of its extent, is accounted for; and since the posterior lobe reaches further beyond the corpus callosum than the anterior, the greater thickness behind is also explained.

Lateral Ventricles, or, *ventriculi tricornes.*—By dividing the fibres of the corpus callosum in a longitudinal direction at a short distance on each side of the middle line, and about midway between the two ends of the hemispheres, an opening is made into the right and left *lateral ventricles* of the brain. These ventricles form part of the general ventricular space within the cerebrum ; they are serous cavities, and are lined by a delicate epitheliated structure, the *ependyma ventriculorum*, which at certain parts in the adult, and probably throughout its whole extent in the fœtus, is provided with cilia. In the natural state, the walls of the ventricles are moistened internally with a serous fluid, which sometimes exists in considerable quantity, even in a healthy brain.

It was formerly a subject of dispute whether the lining of the ventricles consisted of epithelium only, or also of a membrane. The progress of the histology of the brain has solved the problem in a manner which leaves the disputants on both sides partially in the right. It is now recognised, that a peculiar form of connective tissue is found throughout the substance of the brain, similar to that which has been described in the spinal cord. A layer of this substance, unmixed with nerve tissues, but in direct continuity with the interstitial web, and not a distinct membrane, supports the epithelium. It is of the same nature as the substance immediately surrounding the central canal of the spinal cord, and is named by Virchow *neuroglia* (Virchow's "Cellular Pathology," by Chance, p. 273).

The form of the epithelial cells appears to vary in different parts, these cells being, according to Kölliker, of the flat pavement kind in the third ventricle, and more spherical in the lateral ventricles; and, according to Gerlach, cylindrical in the aqueductus Sylvii.

From the central part or body of each lateral ventricle the cavity is extended into each of the three lobes of the hemisphere, thus forming an *anterior*, a *posterior*, and a *middle* or *descending cornu*.

The *body* of each lateral ventricle is roofed in by the corpus callosum, and is separated from its fellow by a vertical partition, the *septum lucidum*, which descends from the corpus callosum to the fornix. In the floor of the ventricle there is seen most posteriorly one half of the *fornix*, which is a thin layer of white brain-substance, broad behind and narrow in front : external and anterior to this is the *choroid plexus of the lateral ventricle*, a red vascular fringe, forming the border of the *velum interpositum*, a fold of pia mater extending inwards, on which the fornix rests : external and anterior to the choroid plexus is the anterior and outer part of the *optic thalamus*, appearing from beneath it : outside and in front of the thalamus is the *corpus striatum* ; and between those two bodies is a narrow flat band, the *tænia semicircularis*.

The *anterior cornu* is the blind anterior extremity of the ventricle, projecting a little way into the anterior lobe. It is covered by the corpus callosum, and turns forwards and outwards round the anterior free extremity of the corpus striatum, descending as it proceeds, and bounded behind by that body, and in front by the reflected part of the corpus callosum.

The *middle* or *descending cornu* turns round the back part of the optic

thalamus, which appears in its cavity and forms its anterior boundary, while its remaining boundaries are formed by the hemisphere. At its commencement it is directed backwards and outwards, then passing downwards with a sweep, it curves forwards, and at its extremity has a marked inclination inwards. The principal object seen upon the floor of this cornu is the *hippocampus major* (pes hippocampi, or cornu ammonis), a large white eminence extending the whole length of the cornu. The hippocampus major becomes enlarged towards its anterior and lower extremity, and is indented or notched on its edge, so as to present some resemblance to the paw of an animal, whence, no doubt, its name of pes hippocampi. The white fibres of its surface are directed obliquely backwards and outwards across it : they form only a thin smooth layer, and beneath them is cineritious matter continuous with that of the surface of the hemisphere. Along the inner edge of this eminence is seen a narrow white band, named *corpus fimbriatum* or *tænia hippocampi*, which is prolonged from the fornix ; to the inner side of the tænia is a part of the choroid plexus, and next to that the back of the optic thalamus. This cornu differs from the others in respect that it is not a mere cul-de-sac, but, by the mere separation of the membranes, can be made to communicate in its whole length with the surface of the brain by the fissure through which the choroid plexus enters.

Fig 372.

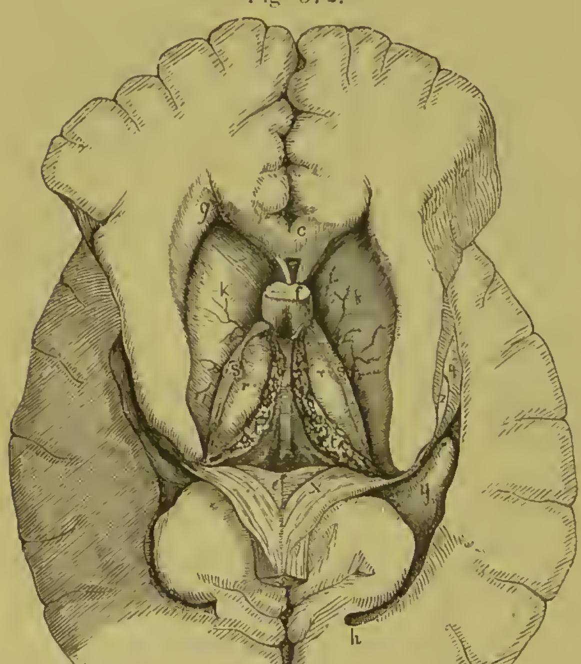


Fig. 372.—A Deep View of the Lateral Ventricles and their Cornua with the Velum Interpositum. ½

The fornix has been divided near its anterior pillars and turned back. *c*, the anterior part of the corpus callosum divided ; *c*, the lyra on the lower surface of the corpus callosum and fornix ; *f*, anterior pillars of the fornix divided (these are represented of too large a size) ; *g*, anterior, and *h*, posterior cornu of the lateral ventricle ; *k*, *k*, corpora striata ; *q*, pes hippocampi in the lower part of the middle cornu ; *r*, *r*, thalami optici ; *s*, *s*, tænia semicircularis ; *t*, *t*, choroid plexus ; *v*, velum interpositum ; *x*, *x*, posterior pillars of the fornix ; *y*, eminentia collateralis.

The *posterior cornu* projects backwards into the substance of the posterior lobe. At its extremity it is pointed, and directed inwards. On the inner side of its floor is a curved and pointed longitudinal eminence, named *hippocampus minor*, *ergot*, or *calcar avis* ; and at the junction of the posterior with the descending cornu, between the hippocampus major and minor, is a smooth eminence, named *eminentia collateralis*, or *pes accessorius*.

Tho hippocampus minor is only the convex side of the fold which forms the calcarine sulcus, and part of the sulcus of tho hippocampi ; and in like

manner the eminentia collateralis corresponds with the posterior branch of the fissure of Sylvius.

As some discussion has recently taken place in this country with regard to the value of the presence of the hippocampus minor in man, as a distinctive character of the human brain, it may be well to mention that this structure has been found even in the brains of quadrumana which do not belong to the highest group. In the human subject the posterior cornu varies greatly in size, and the hippocampus minor is still more variable in its development, being sometimes scarcely to be recognised, and at others proportionally large. It is usually most developed where the posterior cornu is longest: but length of the posterior cornu, and prominence of the hippocampus minor, by no means occur in proportion to the dimensions of the hemisphere, but rather seem to be associated with thinness of both the medullary and cortical substance.

The *septum lucidum* is a thin translucent partition, placed between the two lateral ventricles. It extends vertically between the corpus callosum above, and the anterior part of the fornix below; and as the latter sinks down in front away from the corpus callosum, the septum is deep before and narrow behind. Anteriorly it lies in the hollow of the bend of the corpus callosum, in front of the fornix.

The septum lucidum is double, being composed of two distinct laminæ, having an interval between them, which contains fluid and is lined by an epitheliated membrane. This is the *fifth ventricle, ventricle of the septum*, or *Sylvian ventricle.*

Each of the laminæ of the septum which form the sides of the fifth ventricle, consists of an internal layer of white substance and an external layer of grey matter.

In the human embryo, and also in some animals, the cavity of this ventricle communicates with that of the third ventricle in front and below; but in the adult human brain it forms a separate and insulated cavity. Tarin described a small fissure in it between the pillars of the fornix; but this is unusual. In disease it is sometimes distended with fluid.

The *fornix* is an arched sheet of white longitudinal fibres, which appears partly in the floor of both lateral ventricles. It consists of two lateral halves, which are separated from each other in front and behind, but between those points are joined together in the mesial plane. The two parts in front form the *anterior pillars* of the fornix; the middle conjoined part is named the *body*; and the hind parts, which are again separated from each other, form the *posterior pillars.*

The *body* of the fornix is triangular in shape, being broad and flattened behind, where it is connected with the under surface of the corpus callosum, and narrower in front as it dips down to leave that body,—the space between them being filled up by the septum lucidum. Its lateral edges are in contact with the choroid plexuses, and its under surface rests upon the velum interpositum.

The *anterior crura* or *pillars* of the fornix, cylindrical in form, descend, slightly apart from each other, through a quantity of grey matter on the sides of the third ventricle, between the corpora striata; and, curving backwards as they descend, reach the corpora albicantia. There each crus turns upon itself, making a twisted loop which forms the white portion of the corpus albicans of its own side, and ascends to enter the substance of the optic thalamus. These crura are connected with the peduncles of the pineal gland, and with the tænia semicircularis, as will be afterwards described.

Immediately behind the anterior pillars, where they descend, the fornix, which further back rests upon the optic thalami, the velum interpositum alone intervening, has an interval on each side left between it and the groove where the optic thalamus and corpus striatum meet. This interval leads from the lateral ventric'e to the third ventricle,—the space between the thalami and beneath the velum interpositum. The openings of opposite sides, passing downwards and backwards, meet in the middle line below, and thus is produced a passage, single below, but dividing into two branches above somewhat like the letter Y, and forming a communication between the third ventricle and both lateral ventricles. This passage is named the *foramen of Monro*, or *foramen commune anterius.*

Fig. 373.

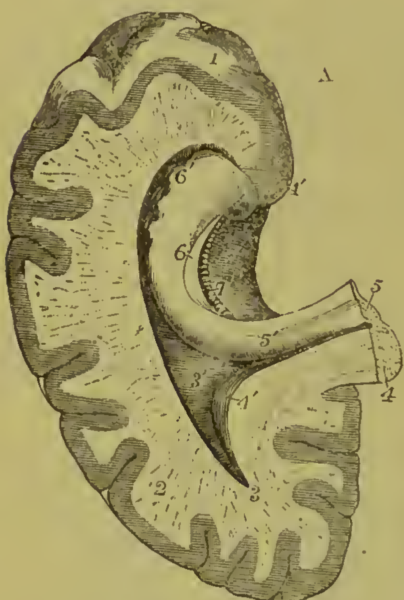


Fig. 373, A.—Lower and Back Part of the Cerebrum of the Left Side, showing the Posterior and Middle Cornua of the Lateral Ventricle opened (altered from Hirschfeld and Leveillé). $\frac{1}{2}$

1, 1′, inner convolution of the temporal lobe turning round into the convolution of the gyrus fornicatus, and showing on its surface the reticulated structure; 2, cut surface of the cerebral hemisphere; 3, point of the posterior cornu of the lateral ventricle; 3′, eminentia collateralis; 4, cut surface of the lower and back part of the corpus callosum divided near the middle; 4′, placed on the extension of the corpus callosum into the cerebral hemisphere, points by a line to the hippocampus minor in the posterior cornu; 5, cut edge of the posterior pillar of the fornix passing down at 5′, into the hippocampus major and corpus fimbriatum; 6, continuation of the corpus fimbriatum or tænia hippocampi; 6′, pes hippocampi; 7, fascia dentata on the inside of the white substance of the tænia.

B.

Fig. 373, B.—Section of the Hippocampus Major to show the arrangement of the Grey and White Substance (from Mayo).

a, white layer on the surface of the hippocampus; *b*, grey substance which is involuted from the surface of the neighbouring convolution; *c*, fascia dentata; *d*, white reticulated substance of the lower part of the gyrus fornicatus; *e*, cavity of the lateral ventricle.

The *posterior crura* or *pillars* of the fornix are the diverging continuations backwards of the two flat lateral bands of which the body is composed. At first they adhere to the under surface of the corpus callosum, then curving outwards, each crus enters the descending cornu of the corresponding lateral ventricle, and is prolonged as a narrow band of white matter, named *tænia hippocampi* or *corpus fimbriatum*, which is situated on the inner margin of the hippocampus major, and extends to the extremity of that structure.

On examining the under surface of the fornix and corpus callosum, there is seen posteriorly the thickened border or pad, and in front of it the diverging

halves of the fornix, between which a triangular portion of the corpus callosum appears, marked with transverse, longitudinal, and oblique lines. To this part the term *lyra* has been applied.

The transverse fissure of the cerebrum is the passage by which the pia mater passes from the surface into the ventricles of the brain to form the choroid plexus. It may be laid open in its whole extent, after the lateral ventricles have been opened, by completely dividing the fornix and corpus callosum in the middle line, and raising the divided parts from the undisturbed velum interpositum below. It will then be found that, in like manner, the posterior and middle lobes of the brain, including hippocampus major and corpus fimbriatum, may be raised from the subjacent parts as far as the extremity of the descending cornu of the lateral ventricle. The transverse fissure is, therefore, a fissure extending from the extremity of the

Fig. 374.

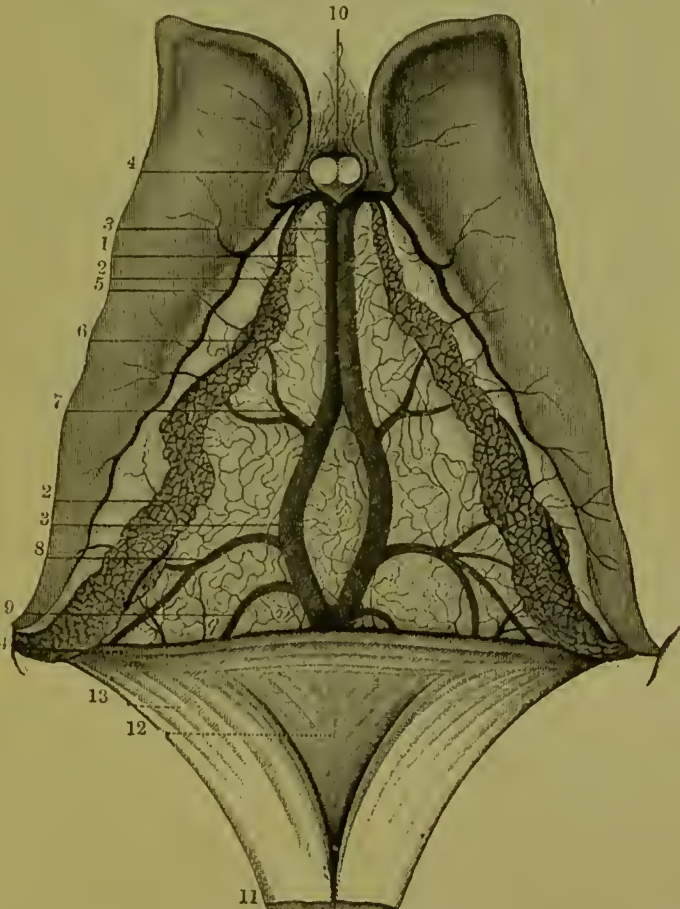


Fig. 374.—View of the Upper Surface of the Velum Interpositum, Choroid Plexus, and Corpora Striata (from Sappey after Vicq-d'Azyr). ⅔

1, fore part of the tela choroidea or velum interpositum ; 2, choroid plexus ; 3, left vein of Galen partly covered by the right ; 4, small veins from the front of the corpus callosum and the septum lucidum ; 5, veins from the corpus striatum ; 6, convoluted marginal vein of the choroid plexus ; 7, vein rising from the thalamus opticus and corpus striatum ; 8, vein proceeding from the inferior cornu and hippocampus major ; 9, one from the posterior cornu ; 10, anterior pillars of the fornix divided in front of the foramen of Monro ; 11, fornix divided near its fore part and turned backwards ; 12, lyra ; 13, posterior pillar united with, 14, the corpus callosum behind, and covered by the choroid plexus as it descends into the inferior cornu.

descending cornu on one side, over the constricted part of the cerebrum, to the extremity of the descending cornu of the other side. It is bounded above by the corpus callosum and fornix in the middle, and more externally on each side by a free margin of the hemisphere: inferiorly it is bounded near the middle line by the corpora quadrigemina, and on each side by the crus cerebri and posterior part of the optic thalamus.

In *the free margin of the hemisphere* brought into view by opening out the part of the transverse fissure which leads into the descending cornu of the lateral ventricle, there are seen (1st) the ribbon-like ledge formed by the corpus fimbriatum, internal to the hippocampus major; (2nd) beneath this, a small grey indented ridge, the *fascia dentata;* and (3rd) beneath the fascia dentata the gyrus hippocampi. On making a transverse section, it is seen that the corpus fimbriatum is the free margin of the white substance of the hemisphere, and that the fascia dentata is the free margin of the cortical substance, and is continuous with the grey matter of the hippocampus major, and that thus the hippocampus major is the swelling in reverse of the sulcus between the fascia dentata and gyrus hippocampi. The fascia dentata can be traced up to the pad or bourrelet: its upper part is free of dentations, and is sometimes named *fasciola cinerea.* The dentations correspond with blood-vessels passing to and from the choroid plexus.

The *velum interpositum* or *tela choroidea,* the membrane which connects the choroid plexuses of the two sides together, is a prolongation of the pia mater through the transverse fissure. It corresponds in extent with the fornix, which rests upon its upper surface; and its more highly vascular free borders, projecting into the lateral ventricles, form the choroid plexuses.

The *choroid plexuses* appear like two red knotted fringes, reaching from the foramen of Monro, where they meet together beneath the fornix, to the point of each descending cornu. They consist of a highly vascular villous membrane. The villi with which they are covered are again divided upon their surfaces and at their borders into smaller processes, along which fine vessels are seen to run. Numerous small vessels pass between the plexuses and the surface of the corpora striata, as well as other neighbouring parts, and the epithelium of the ventricles is continued over their surface. Thus it is only at the foramen of Monro that the epithelial lining of the lateral ventricles is continuous with that of the third ventricle.

The epithelium changes its character where it covers the plexus. It is there composed of large spheroidal corpuscles, in each of which is seen, besides a distinct nucleus, several yellowish granules, and one or more dark round oil-drops. According to Henle each of these cells is provided with short, slender, acuminate, transparent, and colourless processes.

On raising the velum interpositum, two slight vascular fringes are seen running along its under surface, and diverging from each other behind. They form the *choroid plexuses* of the third ventricle.

The choroid artery enters the velum interpositum at the point of the descending cornu; and other arteries enter from behind, beneath the corpus callosum. The greater number of the veins terminate in two principal vessels named the veins of Galen, which run backwards on the velum interpositum, and passing out beneath the corpus callosum pour their blood into the straight sinus, having generally first united into a single trunk.

Bichat supposed that the arachnoid membrane entered the third ventricle in the form of a tubular process, which passed beneath the posterior end of the corpus callosum and fornix, through the velum interpositum, and thus opened into the

upper and back part of the third ventricle. The existence of this canal, named the *canal of Bichat*, is no longer admitted.

The velum having been removed, the optic thalami are brought fully into view, together with the cavity of the third ventricle situated between them, while, behind the third ventricle, between it and the upper surface of

Fig. 375.

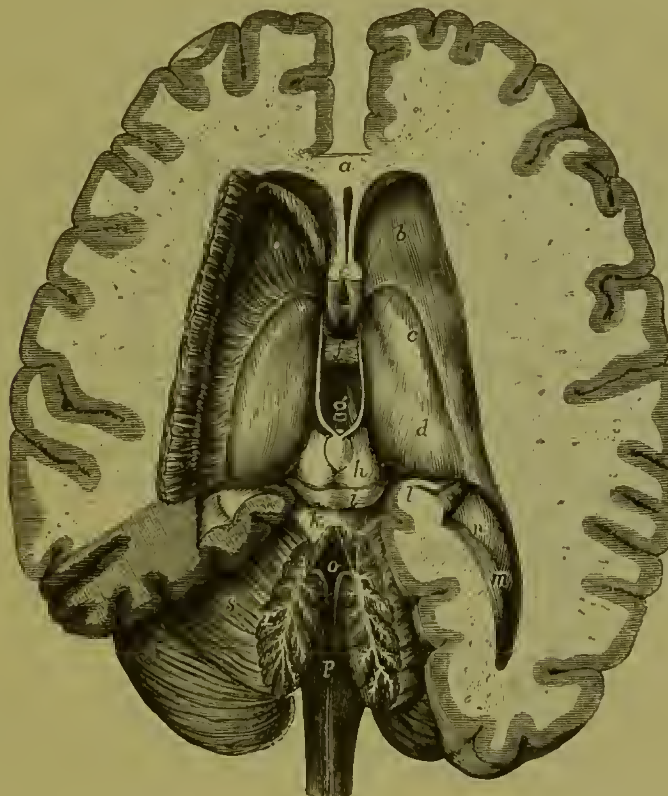


Fig. 375.—Dissection of the Brain from above, exposing the Lateral, Third and Fourth Ventricles, with the surrounding parts (from Hirschfeld and Leveillé). ½

a, the anterior part or knee of the corpus callosum divided ; its fibres are seen spreading on each side into the cerebral hemispheres ; *b*, anterior part of the surface of the right corpus striatum in the anterior cornu of the lateral ventricle ; *b′*, the same on the left side, in which the grey substance has been dissected so as to show the peduncular medullary fibres spreading through the corpus striatum into the cerebral hemisphere ; *c*, points by a line to the tænia semicircularis ; *d*, surface of the thalamus opticus ; *e*, the anterior pillars of the fornix divided ; below they are seen descending in front of the third ventricle, and between them is seen a part of the anterior commissure ; above the letter is seen the fifth ventricle represented as a slit between the two laminæ of the septum lucidum ; *f*, placed on the soft or middle commissure ; *g*, in the posterior part of the third ventricle ; on either side of this letter is the white stria or peduncle of the pineal gland ; immediately below the letter is the small posterior commissure and the pineal gland ; *h*, the upper, and *i*, the lower of the corpora quadrigemina ; *k*, processus a cerebello ad cerebrum ; and close to this the valve of Vieussens, which is partly divided by a median incision along with the middle lobe of the cerebellum, so as to open up the fourth ventricle ; *l*, the hippocampus major and corpus fimbriatum separated from the posterior pillar of the fornix and descending into the middle cornu of the lateral ventricle ; *m*, posterior cornu of the lateral ventricle and hippocampus minor ; *n*, eminentia collateralis ; *o*, the cavity of the fourth ventricle ; *p*, posterior surface of the medulla oblongata ; *r*, section of the middle lobe showing the arbor vitæ ; *s*, upper surface of the cerebellum brought into view on the left side by the removal of a considerable part of the posterior cerebral lobe.

the cerebellum, are seen the pineal body, the corpora quadrigemina, the valve of Vieussens, and the processus a cerebello ad cerebrum.

THE THIRD VENTRICLE is a narrow longitudinal cleft placed between the optic thalami, which bound it on its two sides. It is covered above by the velum interpositum and the fornix. Beneath, its floor is formed by the following parts, which have been already described as seen on the base of the cerebrum, viz., commencing from behind, the posterior perforated space, the corpora albicantia, the tuber cinereum and infundibulum, and the lamina cinerea, the last of which also serves to close it in front, as high as the anterior commissure. Behind, is the anterior opening of the aqueduct of Sylvius. The cavity is crossed by three commissures, named from their position, anterior, middle, and posterior.

The *middle* or *soft commissure* is composed almost entirely of grey matter, and connects the two thalami. It is variable in size, and sometimes wanting ; it is frequently torn across in examining the brain.

The *anterior* commissure is a round bundle of white fibres, placed immediately in front of the anterior pillars of the fornix, and crossing between the corpora striata. It marks the anterior boundary of the ventricle ; its fibres extend laterally through the corpora striata, a long way into the substance of the cerebral hemispheres.

The *posterior commissure*, also white but of smaller size, is placed across the back part of the ventricle, immediately before and below the pineal body, with which and with the corpora quadrigemina it is intimately connected.

The *corpora striata*, situated in front and to the outer side of the optic thalami, are two large ovoid masses of grey matter, the greater part of each of which is embedded in the middle of the white substance of the hemisphere of the brain, whilst a part comes to the surface in the body and anterior cornu of the lateral ventricle. This *intraventricular* portion of the corpus striatum is of a pyriform shape, its larger end being turned forwards, and its narrow end being directed outwards and backwards, so that the optic thalami of the two sides are received between the diverging corpora striata. On cutting into it, there may be seen at some depth from the surface white fibres, which are prolonged from the corresponding cerebral peduncle, and give it the streaked appearance from which it has received its name.

The *extraventricular* portion of the corpora striata will be afterwards described.

Along the inner border of each corpus striatum, and in a depression between it and the optic thalamus, is seen a narrow whitish semitransparent band, named *tænia semicircularis*, which continues backwards into the descending cornu of the ventricle, where its connections have not been determined with precision. In front it reaches the corresponding anterior pillar of the fornix, and descends in connection with that cord of white substance.

It is more transparent and firm on the surface, especially at its fore part : and this superficial stratum has been named *stria cornea*. The tænia consists of longitudinal white fibres, the deepest of which running between the corpus striatum and the thalamus, were named by Vieussens *centrum geminum semicirculare*. Beneath it are one or two large veins, which receive those from the surface of the corpus striatum and end in the veins of the choroid plexuses.

The *thalami optici* (posterior ganglia of the brain) are of an oval shape,

and rest on the corresponding cerebral crura, which they in a manner embrace. On the outer side each thalamus is bounded by the corpus striatum and tænia semicircularis. The upper surface, which is white, is free and prominent, and is partly seen in the lateral ventricle, and partly covered by the fornix. The part which is seen in the lateral ventricle is more elevated than the rest, and is named the *anterior tubercle*. The posterior surface, which is also white and free, projects into the descending

Fig. 376.

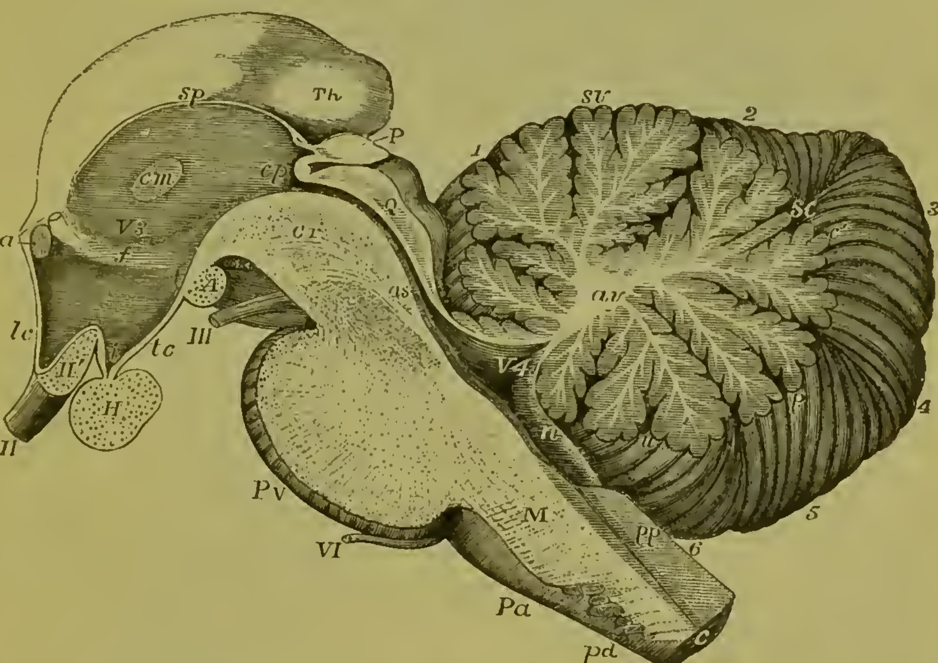


Fig. 376.—Right half of the Encephalic Peduncle and Cerebellum as seen from the inside in a Median Section (after Reichert).

II, right optic nerve; II′, optic commissure divided; III, right third nerve; VI, sixth nerve; V3, third ventricle; *Th*, back part of the thalamus opticus; H, section of the pituitary body; A, corpus albicans; P, pineal gland; *c a*, points by a lower line to the anterior commissure divided, and by an upper line to the divided anterior pillar of the fornix; *lc*, lamina cinerea; *i*, infundibulum (cavity); *tc*, tuber cinereum; *f*, mark of the anterior pillar of the fornix descending in the wall of the third ventricle; *cm*, commissura mollis; *sp*, stria pinealis; *cp*, posterior commissure, above it the peduncle of the pineal gland, and below it the upper end of the passage to the fourth ventricle; Q, corpora quadrigemina (section); *as*, aqueduct of Sylvius near the fourth ventricle; PV, pons Varolii divided in the middle; M, medulla oblongata; *p a*, right anterior pyramid; *pd*, decussating bands cut across; *pp*, posterior pyramids; *c*, central canal with grey substance surrounding it divided. In the cerebellum, *a v*, stem of white substance in the centre of the middle lobe of the cerebellum, ramifying towards the arbor vitæ; *s v*, superior vermiform process or vertical portion of the middle lobe; *s c*, single folium, which passes across between the posterior superior lobes; *c′*, the folia, which unite the posterior inferior lobes; *p*, pyramid; *u*, uvula; *n*, nodule; 1, part of the laminæ of the square lobe; 2, posterior superior lobe; 3, posterior inferior lobe; 4, lobulus gracilis; 5, biventral lobe; 6, amygdaloid lobe.

cornu of the lateral ventricle. The inner sides of the two thalami are in contact one with the other. They present the grey substance of the interior of the thalami uncovered with white, and are generally partially united together by a transverse portion, which forms the middle or soft commissure of the third ventricle.

The *pineal body*, or *gland* (conarium), is a small reddish body, which is placed beneath the back part of the corpus callosum, and rests upon the anterior elevations of the corpora quadrigemina. It is attached to the under surface of the velum interpositum, so that it is liable to be torn away from the brain in removing that membrane. It is about the size of a small cherry-stone. Its base of attachment, which is its broader part, is directed forwards, and is connected with the rest of the cerebrum by white substance. This white substance is principally collected into two small rounded bundles, named *peduncles* of the pineal gland, which pass forwards upon the optic thalami along their upper and inner borders, and may be traced as far as the anterior pillars of the fornix, in conjunction with which they descend. These peduncles are connected with each other behind, and the band of union between them is adherent to the back of the posterior commissure.

This band is represented by Reichert as folding forwards and then backwards, so as to leave a hollow, which he calls *recessus pinealis*, opening backwards above the pineal body. Some anatomists have described two *inferior peduncles*, which descend upon the inner surface of the thalami.

The pineal gland is very vascular. It is hollowed out into two or more cells, which, sometimes at least, open anteriorly into the ventricle, and almost always contain, besides a viscid fluid, a quantity of gritty matter, named *acervulus cerebri*. This consists of microscopic round particles, aggregated into small compound masses, which are again collected into larger groups. It is composed of the so-called amylaceous, or amyloid bodies, and of earthy salts combined with animal matter, viz., phosphate and carbonate of lime, with a little phosphate of magnesia and ammonia (Stromeyer). It is found at all ages, frequently in young children, and sometimes even in the fœtus. It cannot, therefore, be regarded as the product of disease.

This sabulous matter is frequently found on the outside of the pineal body, or even deposited upon its peduncles. It is found also in the choroid plexuses; and scattered corpora amylacea occur in other parts of the membranes of the brain. Huschke has pointed out that the pineal body is larger in the child and the female than in the adult male. In the brains of other mammals it is proportionally larger than in the human subject, and less loaded with the matter of acervulus cerebri.

The *corpora* or *tubercula quadrigemina* are four rounded eminences, separated by a crucial depression, and placed two on each side of the middle line, one before another. They are connected with the back of the optic thalami, and with the cerebral peduncles at either side; and they are placed above the passage leading from the third to the fourth ventricle.

The upper or anterior tubercles are somewhat larger and darker in colour than the posterior. In the adult, both pairs are solid, and are composed of white substance on the surface, and of grey matter within.

They receive bands of white fibres from below, the majority of which are derived from a fasciculus named the fillet. A white cord also passes up on each side from the cerebellum to the corpora quadrigemina, and is continued onwards to the thalami: these two white cords are the *processus a cerebello ad cerebrum*, or superior peduncles of the cerebellum. At each side of the corpora quadrigemina there proceed outwards two white bands, which pass to the thalami and to the commencements of the optic tracts. These bands are prominent on the surface, and are sometimes named *brachia*.

In the human brain the quadrigeminal bodies are small in comparison with those of animals. In ruminant, soliped, and rodent animals, the

Fig. 377.

Fig. 377.—View of the Medulla Oblongata, Pons Varolii, Crura Cerebri, and Central Parts of the Encephalon from the Right Side.

The corpus striatum and thalamus opticus have been preserved in connection with the central lobe and crura cerebri, while the remainder of the cerebrum has been removed. *St*, upper surface of the corpus striatum; *Th*, back part of the thalamus opticus; C, placed on the middle of the five or six convolutions constituting the central lobe or island of Reil, the cerebral substance being removed from its circumference; *Sy*, fissure of Sylvius, from which these convolutions radiate, and in which are seen the white striæ of the olfactory tract; I, the olfactory tract divided and hanging down from the groove in the convolution which lodges it; II, optic nerves a little way in front of the commissure; *a*, right corpus albicans with the tuber cinereum and infundibulum in front of it; *h*, hypophysis or pituitary body; *e*, external, and *i*, internal corpus geniculatum at the back part of the optic tract; P, peduncle or crus of the cerebrum; *f*, fillet; III, right oculo-motor nerve; *p*, pineal gland; *q*, corpora quadrigemina; IV, trochlear nerve rising from *v*, the valve of Vieussens; V, placed on the pons Varolii above the right nervus trigeminus; *s*, the superior, *m*, the middle, and *in*, the inferior peduncles of the crus cerebelli cut short; VI, the sixth nerve; VII *a*, facial nerve; VII *b*, auditory nerve; on the medulla oblongata the parts are indicated as follows: VIII, placed opposite to the cut end of the pneumo-gastric nerve; *a*, the glosso-pharyngeal; and *b*, the uppermost fibres of the spinal accessory nerve; IX, the hypoglossal nerve; *p a*, anterior pyramid; *o*, olivary body; *ar*, arciform fibres; *pp*, posterior pyramid; *r*, restiform body; *tr*, eminence corresponding to the tubercle of Rolando; at the commencement of the spinal cord, *ca*, indicates the anterior, *cp*, the posterior, and *cl*, the lateral columns; CI, anterior and posterior roots of the suboccipital or first cervical nerve.

anterior tubercles are much larger than the posterior, as may be seen in the sheep, horse, and rabbit; and hence the name *nates*, formerly applied to the anterior and *testes* to the posterior tubercles. In the brains of carnivora, the posterior tubercles are rather the larger. In the fœtus of man and mammals these eminences are at first single on each side, and have an internal cavity communicating with the ventricles. They are constant in the brains of all vertebrate animals; but in fishes, reptiles, and birds, in which animals they receive the name of optic lobes, they are only two in number, and hollow: in marsupialia and monotremata, they are also two in number, but are solid.

Optic tracts and *corpora geniculata.*—The optic tracts, which have already been referred to in connection with the base of the cerebrum, are attached to and embrace the under side of the corresponding peduncles, and may be traced back to the thalami. Each tract, somewhat cylindrical towards the optic commissure, becomes flattened and broader as it approaches the thalamus, and makes a bend as it turns round the peduncle to reach the back part of that body. Near this bend, which is named the *knee* (genu), and to the outer side of the corpora quadrigemina, are placed two small oblong and flattened eminences connected with the posterior extremity of the optic tract. They are two little masses of grey matter about the size and shape of coffee beans, placed one on the outer and one on the inner side of the genu of the optic tract, and hence are named respectively *corpus geniculatum externum* and *internum.* They send fibres into the optic tract and also into the thalamus of the same side.

The fibres of the optic tracts are therefore derived from three sources, viz., the thalamus, the tubercula quadrigemina, and the corpora geniculata.

The *processus a cerebello ad cerebrum* are two large white cords extending downwards and somewhat outwards from the corpora quadrigemina to the fore part of the cerebellum, and connecting the latter with the cerebrum. They rest upon the crura cerebri, to which they are united, and between them is the valve of Vieussens.

The *valve of Vieussens* (velum medullare anterius), stretched between the processus a cerebello ad cerebrum, is a thin layer of nervous matter, which lies over the passage from the third to the fourth ventricle, and, lower down, covers in a part of the fourth ventricle itself. It is narrow above, where it is connected with the quadrigeminal bodies, and broader below, where it is continuous with the median portion of the cerebellum.

The upper portion of the valve is composed of white substance, but a few transverse ridges of grey matter extend upon its lower half, as if they were prolonged from the grey lamellæ of the cerebellum with which the valve is there continuous. From between the posterior quadrigeminal tubercles a slight median ridge, named *frænulum,* descends a little way upon the valve; and on the sides of this the commencing fibres of the fourth pair of nerves pass transversely outwards. The back part of the valve is overlapped and concealed by the superior vermiform process of the cerebellum.

INTERNAL STRUCTURE OF THE CEREBRUM.

The cerebrum, like the rest of the encephalon, is composed of white and grey substance, the white pervading nearly the whole of its extent, though more exclusively composing its deeper parts; the grey forming a covering of some thickness over

the whole surface of the convolutions, and collected in distinct masses in certain of the deeper parts, such as the corpora striata, thalami optici, corpora quadrigemina, and crura cerebri. To the grey substance, the names of *cineritious* and *cortical* have been applied; to the white that of *medullary*.

1. *The white matter* of the encephalon consists of tubular fibres, in general still smaller than those of the cord, and more prone to become varicose. The general direction which these follow is best seen in a brain that has been hardened by immersion in alcohol, although it is true that in an ordinary dissection of such hardened masses with the scalpel, we do not then trace the single fibres, but only the smaller bundles and fibrous lamellæ which they form by their aggregation. It must also be admitted that where they intimately decussate, the tearing of fibres across is liable to be mistaken for the separation of sets of fibres one from the other; and it is necessary to correct such errors by the examination of sections under the microscope. The microscopic examination of the cerebrum, however, is as yet still less

Fig. 378.

Fig. 378.—Sketch of a Dissection showing the connection of the Columns of the Medulla Oblongata with the Cerebrum and Cerebellum (from Mayo). ½

In the lower part of the figure the medulla oblongata is entire where it is prolonged downwards into the spinal cord; *a*, the anterior pyramid; *a'*, its continuation upwards into the pons Varolii (*m*); *c*, olivary body; *c'*, olivary fasciculus; behind *c'*, the fasciculi teretes are represented; *d*, the white laminæ in part of the cerebellum; *f*, superior peduncle of the cerebellum; *g*, anterior part or crust of the cerebral peduncle; *h*, part of the fibres radiating from the peduncle into the right cerebral hemisphere, of which a considerable extent is shown containing parts of the anterior, middle, and posterior lobes; *h*, *y*, *y*, part of the corona radiata; *h'* (in front), central fibres of the convolutions; *i*, fillet; *l*, back of the thalamus opticus; *m*, pons Varolii; *n*, inferior peduncle of the crus cerebelli; *o*, section of the pes hippocampi; *r*, tegmentum; *y*, *y*, show the white fibres issuing from the corpus striatum.

complete than that of the spinal marrow and medulla oblongata. By the dissection of artificially prepared brains, aided in part by microscopic observation, the following general facts have been ascertained :—

The fibres of the cerebrum, though exceedingly complicated in their arrangement, and forming many different groups, may be referred to three principal systems, according to the general course which they take, viz. :—1. *Ascending* or

peduncular fibres, which pass up from the medulla oblongata to the hemispheres, and constitute the peduncles of the cerebrum. These fibres increase in number as they ascend through the pons, and still further in passing through the optic thalami and striated bodies, beyond which they spread in all directions into the hemispheres. 2. *Transverse* or *commissural* fibres, which connect the two hemispheres together. 3. *Longitudinal* or *collateral* fibres, which, keeping on the same side of the middle line, connect more or less distant parts of the same hemisphere.

1. In each hemisphere the *peduncular* fibres consist of a main body and of certain accessory bundles of fibres.

The *main body* is derived from the anterior pyramid, from the fasciculi teretes, and from the posterior pyramid. After it has passed through the pons, and become increased in amount, it is separated into two parts in the crus cerebri by a layer of dark cineritious matter, named *locus niger.* The lower or superficial part, which is derived from the pyramid, consists almost entirely of white fibres, collected into coarse fasciculi, and is named the *crust* or *basis,* or the *fasciculated portion* of the peduncle (Foville). The upper part, composed principally of the fasciculus teres and posterior pyramid, is named the *tegmentum.* It is softer and finer in texture, and is mixed with much grey matter.

Still increasing in number within the peduncle, these two sets of fibres ascend to the thalamus and corpus striatum. A much larger number of fibres diverging

Fig. 379.

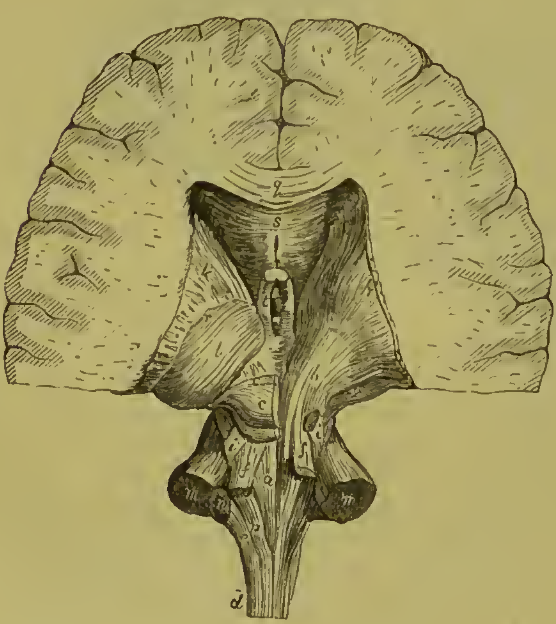


Fig. 379.—Posterior View of the Peduncles of the Cerebrum and Cerebellum (after Arnold). ½

The lower and fore part of the cerebral hemispheres is preserved, the cerebellum is completely detached from its peduncles, and on the right side the corpora quadrigemina and thalamus opticus have been dissected. *a,* fasciculus teres of the left side; *b,* fibres of the tegmentum ascending through the right thalamus; *c,* left corpora quadrigemina; *d,* lateral column of the cord; *e,* restiform body; *f,* superior peduncles of the cerebellum; *g,* fibres of the crust; *i, i,* the fillets; *k, k,* corpora striata; *l,* the left thalamus; *m, m,* sections of the middle peduncles of the cerebellum; *n,* section of the left inferior peduncle; *p,* left posterior pyramid; *q,* section of the corpus callosum; *s,* under surface of the same, and below it the cavity of the fifth ventricle; *t,* left anterior pillar of the fornix; *y,* decussation of the radiating fibres with the crossing fibres of the corpus callosum.

from these bodies appear to pass to the medullary substance of the hemispheres; but the actual continuity of the individual fibres spreading out in the hemisphere with those ascending to the thalamus and corpus striatum is doubted by many authors, and among them, by Kölliker.

The assemblage of radiating fibres in each hemisphere might be compared to a fan, bent into the form of an incomplete hollow cone, having its concave surface turned downwards and outwards; hence the name *corona radiata* applied to them by Reil, and *fibrous cone* by Mayo.

The *accessory fibres* of the peduncular system are as follows :—

a. The superior peduncles of the cerebellum, (processus ad cerebrum,) which are continued up beneath the corpora quadrigemina, and form part of the tegmentum.

b. The bundle of fibres on each side, named the *fillet* (lemniscus). This, which is originally derived from the anterior column of the cord, proceeds from the olivary fasciculus of the medulla oblongata, as previously described. Reinforced by fibres from the corpus dentatum of the olivary body, it ascends through the back part of the pons, still increasing in size. Appearing at the side of the cerebral peduncle, above the upper border of the pons, it divides into two portions, of which one crosses over the superior peduncle of the cerebellum to the corpora quadrigemina, meeting its fellow of the opposite side; while the other is continued upwards with the fibres of the tegmentum.

c. Other fibres accessory to the peduncles take their rise in the grey matter of the corpora quadrigemina (the *brachia*), and proceed on to the thalami.

d. Lastly, fibres of another set, having a similar destination, are derived from the corpora geniculata.

2. The *transverse commissural*, or connecting fibres of the cerebrum, include the following sets :—

a. The cross fibres of the corpus callosum, passing laterally into the substance of

Fig. 380.

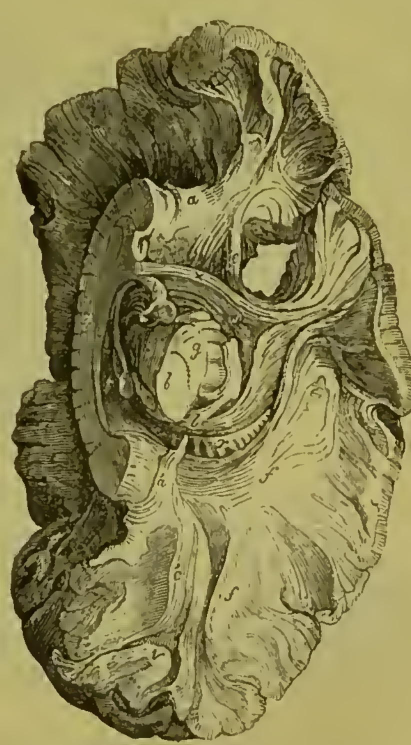


Fig. 380.—View of a Dissection of the Fibres in the Left Cerebral Hemisphere from below (after Mayo). ½

The most of the middle lobe in its lower part has been removed. *a*, the anterior, and *a′*, the posterior part of the fillet of the corpus callosum; *b*, *g*, section of the crus cerebri; *b*, tegmentum; *g*, crust separated from the last by the locus niger; *c′*, fibres stretching from the back part of the corpus callosum into the posterior lobe; *e*, fasciculus uncinatus connecting the anterior and middle lobes across the Sylvian fissure; *f*, *f*, transverse fibres from the corpus callosum passing into the cerebral hemispheres; *l*, back part of the thalamus; *m*, corpus albicans; *q*, median section of the corpus callosum; *r*, radiating fibres of the hemispheres; *t*, anterior pillar of the fornix descending into the corpus albicans (*m*); *v*, collateral fibres of the convolutions; ×, anterior commissure.

the hemispheres, some being directed upwards, whilst others spread outwards on the roof of the lateral ventricles, forming there what is named the *tapetum*. Having intersected the peduncular radiating fibres, they spread out into the hemispheres, reaching everywhere the grey matter of the convolutions.

b. The *fibres of the anterior commissure* pass laterally into the corpora striata, and bending backwards, extend a long way into the middle of the hemispheres, on each side.

c. The *fibres of the posterior commissure* run through the optic thalami, and are soon lost in the substance of the hemispheres outside these bodies.

3. The third system of fibres in the cerebrum, the *longitudinal* or *collateral*, includes those of the fornix, tænia semicircularis, and striæ longitudinales of the corpus callosum, already sufficiently described; and likewise the following :—

a. Fibres of the gyrus fornicatus; fillet of the corpus callosum (Mayo).—These fibres constitute the white substance of the gyrus fornicatus, and take a longitudinal course immediately above the transverse fibres of the corpus callosum. In front

they bend downwards within the gyrus to which they belong, and are connected with the anterior perforated space, being joined by certain longitudinal fibres which run along the under surface of the corpus callosum near the middle line, passing near and upon the upper edge of the septum lucidum. Behind, they turn round the back of the corpus callosum and thence descend to the point of the middle lobe, where, according to Foville, they again reach the perforated space. Offsets from these fibres pass upwards and backwards into the secondary convolutions derived from the gyrus fornicatus in the longitudinal fissure.

b. Fasciculus uncinatus.—Under this name is described a white bundle, seen on the lower aspect of the hemisphere, passing across the bottom of the Sylvian fissure, and connecting the anterior with the middle and posterior lobes. The fibres of this bundle expand at each extremity, and the more superficial of them are curved or hooked sharply between the contiguous parts of the anterior and middle lobes,—whence it has received its name.

c. The convolutions of the cerebrum are connected with each other by white fibres, which lie immediately beneath the cortical substance. Some of them pass across the bottom of the sulcus between adjacent convolutions; whilst others, which are longer and run deeper, connect convolutions situated at a greater distance from one another.

Fig. 381.

Fig. 381.—View of a Dissection of the Fibres of the Gyrus Fornicatus and Fornix in the Right Hemisphere (slightly altered from Foville). $\frac{1}{2}$

A, the anterior lobe; B, the posterior lobe; *a*, *a'*, *a''*, fibres of the gyrus fornicatus; *c*, *c'*, oblique bands of fibres of some of its accessory gyri; *b*, tegmentum, and *g*, crust of the crus cerebri, separated by the locus niger; *l*, thalamus; *m*, fissure of Sylvius; *n*, corpus albicans; *q*, median section of the corpus callosum; *s*, septum lucidum; *t*, the fornix, its anterior pillar descending into the corpus albicans, and then emerging from that at its termination (*) in the thalamus; 1, the olfactory bulb; 2, the optic commissure.

The researches of Foville have led him to differ considerably from other anatomists as to the course of the fibres of the cerebrum, as will be seen from the following statement of his views:—

1. The *crust* or *fasciculated portion* of each cerebral peduncle, derived from the anterior pyramid, forms by itself the peduncular fibrous cone, and is thence continued on into the radiating fibres of the cerebrum, which are destined only for the convolutions on the convex surface of the hemisphere, including the outer half of the marginal convolution of the longitudinal fissure, and the inner half of the convolution of the Sylvian fissure.

2. The fibres of the *tegmentum*, having entered the thalamus, pass on in two ways —no part of them, however, joining the radiating peduncular fibres.

a. One set pass upwards through the thalamus and corpus striatum, above which

they then turn inwards, and, joining with those of the opposite side, form the transverse fibres of the corpus callosum. The corpus callosum is therefore regarded as a commissure of the cerebral peduncles only—none of its cross fibres spreading into the convolutions, as is generally believed.

b. The second set of fibres of the tegmentum, corresponding with the fasciculi teretes and part of the posterior pyramids, run forwards near the middle line, along the under side of the third ventricle and corpus striatum, through the grey matter in front of the pons, to the anterior perforated space. The remaining part of the posterior pyramid forms the tænia semicircularis, which, passing down in front of the anterior pillar of the fornix, also reaches the perforated space. From this space more fibres are reflected upwards on the sides of the corpus striatum to join the corpus callosum.

3. As dependencies of the posterior peduncular fibres, and connected with them at the borders of the anterior perforated space, are :—

a. Several sets of longitudinal arched fibres, which embrace, in a series of rings, the radiating peduncular system. These are—the deep fibres of the tænia semicircularis—a somewhat similar band beneath the outer part of the corpus striatum—the half of the fornix with the corpus fimbriatum—the longitudinal fibres placed on the upper and under surface of the corpus callosum, and those of the septum lucidum; and, lastly, two remarkable systems of longitudinal fibres — one constituting the entire white substance of the gyrus fornicatus (from end to end), also of its accessory convolutions, and of the inner half of the marginal convolution of the longitudinal fissure; and the other, forming the white substance of the convolutions of the island of Reil, and the adjoining half of the convolution of the Sylvian fissure. None of the parts just named receive fibres from the radiating peduncular set.

b. In connection with this system is a thin stratum of white fibres, found upon the internal surface of the ventricles, and prolonged through the transverse fissure into the reticulated white substance covering the lower end of the gyrus fornicatus; whence, according to Foville, it extends, as an exceedingly thin layer of medullary matter, all over the cortical substance of the hemisphere.

c. The anterior commissure does not reach the convolutions, but radiates upon the outer sides of the corpora striata and thalami.

II. *The grey matter on the convoluted surface* of the cerebrum is divided into two and in some regions into three strata, by interposed thin layers of white substance. In examining it from without inwards, we meet with—1. A thin coating of white matter situated on the surface, which on a section appears as a faint white line, bounding the grey substance externally. This superficial white layer is not equally

Fig. 382.

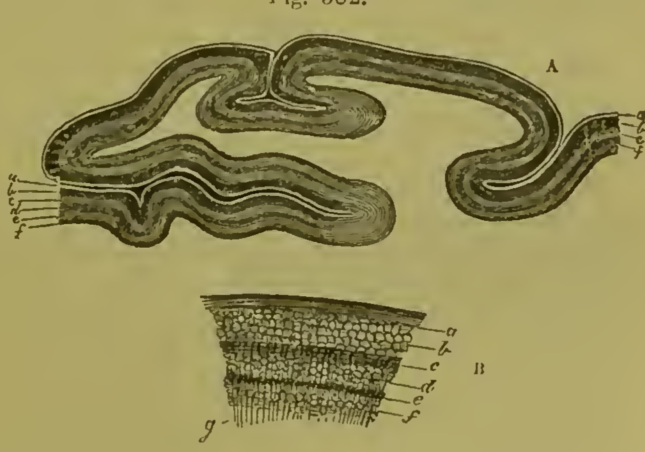


Fig. 382.—Section of the Cortical Substance of a Cerebral Convolution (from Remak).

In A, the parts are nearly of the natural size. To the right of the figure, *a* and *e* are two white, and *b* and *f* two grey strata; to the left of the figure, an additional white layer, *c*, divides the first grey into two, *b* and *d*. In B, a small part of the cortical substance of a convolution is represented, magnified to show more clearly the relative position of the strata; *a*, superficial white layer; *b*, reddish grey layer; *c*, intermediate white layer; *d*, inner part of the outer grey layer; *e*, thin white layer; *f*, inner grey layer; *g*, radiating white fibres from the medullary substance of the convolution passing into the layers of the cortical substance.

thick over all parts of the cortical substance, but becomes thicker as it approaches the borders of the convoluted surface; it is accordingly less conspicuous on the lateral convex aspect of the hemispheres, and more so on the convolutions situated in the longitudinal fissure which approach the white surface of the corpus callosum, and on those of the under surface of the brain. It is especially well marked on the middle lobe, near the descending cornu of the lateral ventricle, where the convoluted surface is bounded by the posterior pillar of the fornix, and it has been there described under the name of the *reticulated white substance.* It consists of remarkably fine tubular fibres, for the most part varicose, which run parallel with the surface of the convolutions, but intersect each other in various directions. The termination and connections of these fibres are unknown. This superficial white layer contains also a few small cells with processes, and an abundant granular matrix. 2. Immediately beneath the white layer just described, is found a comparatively thick layer of grey or reddish grey matter, the colour of which, as indeed of the grey substance generally, is deeper or lighter according as its very numerous vessels contain much or little blood. Then follow, 3. Another thin whitish layer; and, 4. A thin grey stratum. This last lies next to the central white matter of the hemisphere. Remak considers it as similar in nature to the gelatinous substance of the spinal cord. According to this account, the cortical substance consists of two layers of grey substance, and two of white; but in several convolutions, especially those situated near the corpus callosum, a third white stratum may be seen, which divides the most superficial grey layer into two, thus making six in all, namely, three grey and three white.

Fig. 383.

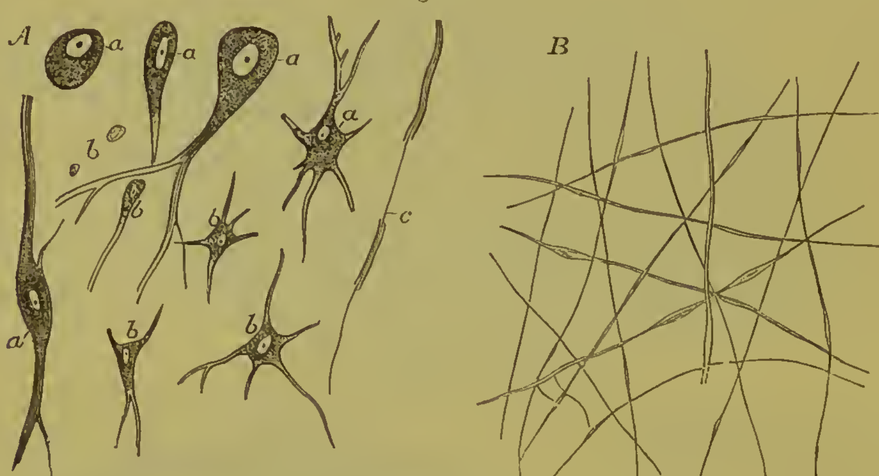


Fig. 383.—Minute Structure of the Cerebral Substance (from Kölliker), magnified 220 diameters.

A, cells and structural elements from the inner part of the cortical substance of the cerebral convolutions: *a*, larger cells, chiefly from the middle grey layer, showing a variable number of radiating processes; *b*, smaller cells from the more superficial grey layer, in part belonging to connective tissue; *c*, a nerve fibre with its axis-filament partly exposed.

B, finest nerve fibres from the superficial white layer of the cortical substance of a convolution, some showing the varicose condition.

The cortical grey substance consists of nerve-cells of rather variable size, which are angular, fusiform, round or oval in shape, and for the most part caudate, and lie in a granular matrix; also of small nucleus-like vesicles, which resemble those seen in the cortical substance of the cerebellum, and, according to Todd, are here also collected into a special stratum. In the middle grey layer, the cells are of variable size, some being so small as to resemble nuclei; but others of much larger dimensions are abundant, and, according to Kölliker, present from one to six processes.

In the innermost grey layer the cells have similar characters, but often contain pigmentary matter. Tubular fibres exist throughout: those of one set run parallel with the surface, and at certain depths are more densely aggregated, so as to form the before-mentioned white layers: they are also present in the intervening grey strata, but there they are wider apart. The manner in which they begin and end is not known; it seems not improbable, however, that they are dependencies of the commissural system of fibres. These stratified fibres, if they might be so called, are intersected by another set of tubular fibres, which come from the central white mass of the hemispheres, and run perpendicularly through the cortical substance, becoming finer and spreading more out from each other as they approach the surface.

The further disposition of these central or perpendicular fibres is uncertain; Valentin describes them as forming terminal loops or arches, but this is denied by Remak and Hannover. Remak states that they gradually disappear from view at different depths, as they pass through the successive layers, the last of them vanishing in the superficial grey stratum; but he is unable to say positively how they terminate. It sometimes seemed to him as if the last of them, after intersecting the fibres of the deeper white stratum, became continuous with those of the outermost layer; but of this he by no means speaks confidently. Hannover maintains that the perpendicular fibres are connected at their extremities with the nerve-cells in the cortical substance.

The grey matter of the lamina cinerea, tuber cinereum and posterior perforated spot appears both in the base of the brain and in the floor of the third ventricle. The lamina cinerea is connected externally with the grey matter of the anterior perforated spot, and from that point a continuity of grey matter can be traced to the swelling of the olfactory bulb. Thus also continuity is established between the grey matter of the hemispheres and that of the interior of the brain.

III. *The grey matter of the interior* of the cerebrum may be examined in the series of its deposits from behind forwards.

In the *crura cerebri*, the grey matter is collected into a dark mass, the *locus niger*, which lies between the crust and the tegmentum, and is also diffused among the fasciculi of the tegmentum; below this it is continuous with that of the pons and medulla oblongata, and through them with that of the spinal cord, as has already been sufficiently described. In the upper part of each tegmentum is a round reddish grey centre, the red centre of Stilling, the superior olive of Luys.

In the centre of each of the *corpora quadrigemina* grey matter is also found, and this collection is stated by Huschke to be continuous below with the posterior cornu of the grey matter of the spinal cord, posteriorly with that of the corpus dentatum of the cerebellum, and anteriorly with the soft commissure, the septum lucidum, optic thalami, and corpus callosum. Grey matter occurs also in the pineal gland, and in the corpora geniculata. These last bodies appear to be appendages of the optic thalami.

The grey matter of the *optic thalamus* constitutes the principal bulk of that body; it is, however, partially divided into an inner and an outer portion, by white fibres passing through it.

The *corpus striatum* contains three grey centres. That which forms the intra-ventricular portion of the body, and is connected inferiorly with the lamina cinerea, and with that portion of the grey matter of the optic thalamus which is seen in the third ventricle, is named the *nucleus caudatus*. The principal centre of the extra-ventricular portion, named *nucleus lenticularis*, external and inferior to the nucleus caudatus, is separated from that centre by the white substance of the fibrous cone, which, as it passes outwards, appears, when cut across, as a broad white band extending from behind forwards, and traversed by striæ of grey matter passing from one centre to the other. Between the nucleus lenticularis and the island of Reil, which lies opposite to it, there intervenes a thin lamelliform deposit of grey matter, the *nucleus tæniæformis* (Arnold), or *claustrum* (Burdach), which, in a transverse section, is seen as a thin line. The lenticular nucleus is continuous with the grey matter of the anterior perforated space.

The corpus striatum and optic thalamus contain cells very much like those of the cortical substance. In the corpora quadrigemina there are larger cells, approaching in size to those of the cerebellum, besides very small cells and nucleiform bodies. The dark matter, forming the so-called locus niger of the cerebral peduncles, and

that in the floor of the fourth ventricle, contain caudate cells, many of them of the largest size, with long appendages, and deeply coloured with pigment. (Hannover, Rech. Microscop. sur le Systême Nerveux. Copenhagen, 1844).

The pineal body, like the pituitary body, has already been sufficiently described. The deep connection of some of the cranial nerves with the basal parts of the cerebrum, as well as that of others with the remaining portions of the encephalon, will be referred to in the description of these nerves.

THE MEMBRANES OF THE BRAIN AND SPINAL CORD.

The cerebro-spinal axis is protected by three *membranes*, named also *meninges*. They are :—1. An external fibrous membrane, named the *dura mater*, which closely lines the interior of the skull, and forms a loose sheath in the spinal canal ; 2. An internal areolo-vascular tunic, the *pia mater*, which accurately covers the brain and spinal cord ; and 3. An intermediate serous sac, the *arachnoid* membrane, which, by its parietal and visceral layers, covers the internal surface of the dura mater on the one hand, and is reflected over the pia mater on the other.

THE DURA MATER.

The *dura mater*, a very strong dense inelastic fibrous tunic of considerable thickness, is closely lined on its inner surface by the outer portion of the

Fig. 384.

Fig. 384.—The Cranium opened to show the Falx of the Cerebrum, and Tentorium of the Cerebellum. ½

a, right side of the falx cerebri ; *a′*, its anterior narrow part attached to the crista galli ; *b*, tentorium cerebelli of the right side, united to the base of the falx cerebri from 2 to 3, in the line of the straight sinus, and attached to the superior border of the petrous bone between 3 and 3′ ; *b′*, aperture between the right and left divisions of the tentorium for the isthmus cerebri ; 1, 1, the superior longitudinal sinus ; 2, 2, the inferior ; 3, 3, the lateral sinus ; 3, 3′, the superior petrosal sinus ; 3′, is close to the anterior clinoid process.

arachnoid, and with it, therefore, forms a *fibro-serous* membrane, which is free, smooth, and epitheliated on its inner surface, where it is turned towards the brain and cord, but which, by its outer surface, is connected with the surrounding parts, in a somewhat different manner in the cranium and in the spinal canal.

The outer surface of the *cranial* portion adheres to the inner surface of the bones, and forms their internal periosteum. The connection between the two depends, in a great measure, on blood-vessels and small fibrous processes, which pass from one to the other; and the dura mater, when detached and allowed to float in water, presents a flocculent appearance on its outer surface, in consequence of the torn parts projecting from it. The adhesion between the membrane and the bone is more intimate opposite the sutures, and also generally at the base of the skull, which is uneven, and perforated by numerous foramina, through which the dura mater is prolonged to the outer surface, being there continuous with the pericranium. The fibrous tissue of the dura mater becomes blended with the areolar sheaths of the nerves, at the foramina which give issue to them.

In leaving the skull, the dura mater is intimately attached to the margin of the foramen magnum; but within the vertebral canal it forms a loose sheath around the cord (*theca*), and is not adherent to the bones, which have an independent periosteum. Towards the lower end of the canal, a few fibrous slips proceed from the outer surface of the dura mater to be fixed to the vertebræ. The space intervening between the wall of the canal and the dura mater is occupied by loose fat, by watery areolar tissue, and by a plexus of spinal veins.

Opposite each intervertebral foramen the dura-matral theca presents two openings, placed side by side, which give passage to the two roots of the corresponding spinal nerve. It is continued as a tubular prolongation on the nerve, and is lost in its sheath. Besides this, it is connected with the circumference of the foramen by areolar tissue.

The fibrous tissue of the dura mater, especially within the skull, is divisible into two distinct layers, and at various places these layers separate from each other and leave intervening channels, called *sinuses*. These sinuses, which have been elsewhere described, are canals for venous blood, and are lined with a continuation of the internal membrane of the veins.

The dura mater also sends inwards into the cavity of the skull three strong membranous *processes*, or *partitions*, formed by duplication of its inner layer. Of these, one descends vertically in the median plane, and is received into the longitudinal fissure between the two hemispheres of the cerebrum. This is the *falx cerebri*. The second is an arched or vaulted partition, stretched across the back part of the skull, between the cerebrum and the cerebellum; it is named the *tentorium cerebelli*. Below this, another vertical partition, named *falx cerebelli*, of small extent, passes down between the hemispheres of the cerebellum.

The *falx cerebri* is narrow in front, where it is fixed to the crista galli, and broader behind, where it is attached to the middle of the upper surface of the tentorium, along which line of attachment the straight sinus is situated. Along its upper convex border, which is attached above to the middle line of the inner surface of the cranium, runs the superior longitudinal sinus. Its under edge is free, and reaches to within a short distance of the corpus callosum, approaching nearer to it behind. This border contains the inferior longitudinal sinus.

The *tentorium*, or *tent*, is elevated in the middle, and declines downwards

in all directions towards its circumference, thus corresponding in form with the upper surface of the cerebellum. Its inner border is free and concave, and leaves in front of it an oval opening, through which the isthmus encephali descends. It is attached behind and at the sides by its convex border to the horizontal part of the crucial ridges of the occipital bone, and there encloses the lateral sinuses. Farther forward it is connected with the upper edge of the petrous portion of the temporal bone—the superior petrosal sinus running along this line of attachment. At the point of the pars petrosa, the external and internal borders meet, and may be said to intersect each other—the former being then continued inwards to the posterior, and the latter forwards to the anterior clinoid process.

The *falx cerebelli* (falx minor) descends from the middle of the posterior border of the tentorium with which it is connected, along the vertical ridge named the internal occipital crest, towards the foramen magnum, bifurcating there into two smaller folds. Its attachment to the bony ridge marks the course of the posterior occipital sinus, or sinuses.

Structure.—The dura mater consists of white fibrous and elastic tissue, arranged in bands and laminæ, crossing each other. It is traversed by numerous blood-vessels which are chiefly destined for the bones. Minute nervous filaments, derived from the fourth, fifth and eighth cranial nerves, and from the sympathetic, are described as entering the dura mater of the brain. Nervous filaments have likewise been traced in the dura mater of the spinal column. (Luschka and Rüdinger, quoted by Hyrtl.)

THE PIA MATER.

The *pia mater* is a delicate, fibrous, and highly vascular membrane, which immediately invests the brain and spinal cord.

Upon the hemispheres of the brain it is applied to the entire cortical surface of the convolutions, and dips into all the sulci. From its internal surface very numerous small vessels enter the grey matter and extend for some distance perpendicularly into the substance of the brain. The inner surface of the cerebral pia mater is on this account very flocculent, and is named *tomentum cerebri.* On the cerebellum a similar arrangement exists, but the membrane is finer and the vessels from its inner surface are not so long. The pia mater is also prolonged into the ventricles, and there forms the velum interpositum and choroid plexuses.

Structure.—The pia mater consists of interlaced bundles of areolar tissue, conveying great numbers of blood-vessels; and, indeed, its peculiar office, both on the brain and spinal cord, seems to be that of providing a nidus or matrix for the support of the blood-vessels, as these are subdivided before they enter the nervous substance. According to Fohmann and Arnold it contains numerous lymphatic vessels. Purkinje describes a retiform arrangement of nervous fibrils, derived, according to Kölliker and others, from the sympathetic, the third, sixth, facial, pneumogastric and accessory nerves.

On the *spinal* cord the pia mater has a very different structure from that which it presents on the encephalon, so that it has even been described by some as a different membrane under the name *neurilemma of the cord.* It is thicker, firmer, less vascular, and more adherent to the subjacent nervous matter: its greater strength is owing to its containing fibrous tissue, which is arranged in longitudinal shining bundles. A reduplication of this membrane dips down into the anterior fissure of the cord, and serves to conduct blood-vessels into that part. A thinner process passes into the greater part of the posterior fissure. At the roots of the nerves, both in the spine and

in the cranium, the pia mater becomes continuous with the neurilemma. It is supplied with nerves from the sympathetic.

Towards the upper part of the cord, the pia mater presents a greyish mottled appearance, which is owing to pigment particles deposited within its tissue.

THE ARACHNOID MEMBRANE.

The *arachnoid* is a very fine delicate serous membrane, which, like other membranes of that class, forms the lining boundary of a shut sac. The walls of this sac consist of two portions, one of which, a distinct membrane on the surface of the pia mater, is the visceral or cerebral layer of the arachnoid, while the other, giving the smooth surface presented by the dura mater on its interior, is described by some anatomists as the parietal layer of the arachnoid, while, according to the view taken by others, it is merely the serous surface of the dura mater.

The *parietal* wall of the arachnoid space is invested with a layer of polygonal epithelial cells, which are flattened and nucleated. Besides this, it presents in the greater part of its extent no tissue distinct from the dura mater; and hence it is that Kölliker and others object to the term parietal layer of the arachnoid membrane as applied to the structure of this surface. It may be mentioned, however, that in certain recesses, as for example at the sides of the crista galli, and between the trabeculæ into which the deep fibres of the dura mater are thrown in the neighbourhood of the superior longitudinal sinus, a small amount of delicate connective tissue beneath the epithelium may be distinguished from the dense fibres of the dura mater.

The *visceral layer* of the arachnoid is a distinct transparent membrane which passes over the various eminences and depressions on the cerebrum and cerebellum, without dipping into the sulci and smaller fissures; nor is it uniformly and closely adherent to the pia mater. The interval left between the arachnoid membrane and pia mater is named generally the subarachnoid space.

This *subarachnoid space* is wider and more evident in some positions than in others. Thus, in the longitudinal fissure, the arachnoid does not descend to the bottom, but passes across, immediately below the edge of the falx, at a little distance above the corpus callosum. In the interval thus left, the arteries of the corpus callosum run backwards along that body. At the *base* of the brain and in the *spinal canal* there is a wide interval between the arachnoid and the pia mater. In the base of the brain, this subarachnoid space extends in front over the pons and the interpeduncular recess as far forwards as the optic nerves, and behind it forms a considerable interval between the cerebellum and the back of the medulla oblongata. In the spinal canal it surrounds the cord, forming a space of considerable extent.

A certain quantity of *fluid* is contained between the arachnoid membrane and the dura mater; but it has been shown by Magendie that the chief part of the cerebro-spinal fluid is lodged under the arachnoid, in the subarachnoid space.

Magendie also pointed out the existence of a sort of septum dividing the spinal subarachnoid space at the back of the cord. This is a thin membranous partition, which passes in the median plane from the pia mater covering the posterior median fissure of the cord to the opposite part of the loose portion of the arachnoid membrane. It is incomplete and cribriform; and consists of bundles of white fibres interlaced more or less with one another. Fibrous bands of the same texture pass across the subarachnoid

space in various situations both within the spinal canal and at the base of the brain, stretching thus from the arachnoid membrane to the pia mater.

Fig. 385.

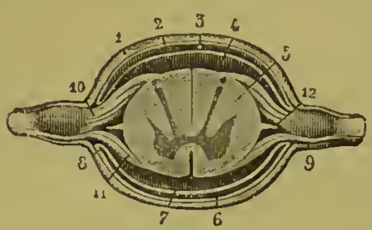


Fig. 385. TRANSVERSE SECTION OF THE SPINAL CORD AND ITS ENVELOPES (from Sappey after Hirschfeld and Leveillé).

1, dura mater or theca; 2, parietal layer of the arachnoid membrane; 3, internal or loose arachnoid; 4 and 7, subarachnoid cavity or space; 5, hinder part of the antero-lateral column; 6, space between the arachnoid and the dura mater, or between the inner and outer folds of the arachnoid membrane; 8, reflection of the one fold into the other; 9, sheath furnished to the spinal nerve by the dura mater; 10, posterior ganglionic root; 11, smaller anterior root; 12, section of the ligamentum denticulatum. This figure does not show the septum which posteriorly divides the subarachnoid space into right and left parts: this would be placed between the arachnoid at 3, and the pia mater covering the posterior surface of the cord.

As the cerebral and spinal nerves proceed to their foramina of exit from within the dura mater, they are loosely surrounded by tubular sheaths of the arachnoid membrane, which extend along each nerve from the visceral to the parietal layer.

Structure.—When examined under the microscope, the visceral or true arachnoid is found to consist of very distinctly separated riband-like bundles of fibrous tissue interlaced with one another, and a simple layer of scaly epithelium on the surface. Volkmann has described a rich plexus of nerves in the arachnoid membrane of certain ruminants. Kölliker has failed to detect their presence; but they have been again described by Bochdalek, who traces them to the portio minor of the fifth, the facial, and accessorius nerves; and they have likewise been followed by Luschka.

Cerebro-spinal fluid.—This is a very limpid serous fluid, which occupies the subarachnoid space. When collected immediately after death, its quantity was found by Magendie in the human subject to vary from two drachms to two ounces. It is slightly alkaline, and consists, according to an analysis by Lassaigne, of 98·5 parts of water, the remaining 1·5 per cent. being solid matter, animal and saline. In experiments made on the dog, it was found by Magendie to be reproduced in thirty-six hours, after it had been drawn off by puncturing the membranes at the lower part of the cord. When pressure is made upon the brain, the quantity of fluid in the spinal subarachnoid space is increased, and conversely, it may be forced from the spinal cavity upwards into the cranium.

Ligamentum denticulatum.—This is a narrow fibrous band which runs along each side of the spinal cord in the subarachnoid space, between the anterior and posterior roots of the nerves, commencing above at the foramen magnum, and reaching down to the lower pointed end of the cord. By its inner edge this band is connected with the pia mater of the cord, while its outer margin is widely denticulated; and its denticulations, traversing the arachnoid space, with the arachnoid membrane reflected over them, are attached by their points to the inner surface of the dura mater, and thus serve to support the cord along the sides and to maintain it in the middle of the cavity. The first or highest denticulation is fixed opposite the margin of the foramen magnum, between the vertebral artery and the hypoglossal nerve; and the others follow in order, alternating with the successive pairs of spinal nerves. In all, there are about twenty-two of these points of insertion. At the lower end, the ligamentum denticulatum

may be regarded as continued into the terminal filament of the spinal cord, which thus connects it to the dura mater at the lower end of the sheath. (See Figures 341 and 342.)

Structure.—It consists of white fibrous tissue, mixed with many exceedingly fine elastic fibres which are seen on applying acetic acid. It is obviously continuous on the one hand with the fibrous tissue of the pia mater, and on the other with that of the dura mater.

The pia mater of the cord presents a conspicuous fibrous band, running down in front over the anterior median fissure. This was named by Haller, *linea splendens.*

Glandulæ Pacchioni.—Upon the external surface of the dura mater, in the vicinity of the longitudinal sinus, are seen numerous small pulpy-looking elevations, generally collected into clusters, named glands of Pacchioni. The inner surface of the calvarium is marked by little pits, which receive these eminences. Similar excrescences are seen on the internal surface of the dura mater, and upon the pia mater on each side of the longitudinal sinus, and also projecting into the interior of that sinus. Occasionally they are found also in other situations.

These bodies are not found at birth; and according to the brothers Wenzel, they exist only in very small number, if at all, before the third year. After the seventh year they are usually found, and they increase in number greatly as life advances; in some cases, however, they are altogether wanting. In animals there appears to be no corresponding structure.

On a careful examination of the connections of these bodies it will be found that the elevations, found on the outer surface of the dura mater and within the longitudinal sinus, in no instance take origin in those positions, but that they are grape-like bodies which are attached more deeply, and in their growth have perforated the dura mater. Their precise origin and nature were long the subject of conflicting opinions, but it has been satisfactorily shown by Luschka that they are only an enlarged condition of normal villi of the arachnoid, and that no other structure is involved in their formation. Their most prolific source is, as one may very soon discover, the cerebral or generally acknowledged layer of the arachnoid, but they likewise arise in a similar manner from the serous surface of the dura mater, and may sometimes be found of all sizes in the recesses into which that surface is thrown in the neighbourhood of the longitudinal sinus. (Luschka, in Müller's Archiv, 1852; and "Die Adergeflechte des Menschlichen Gehirns," 1855. See also Cleland "On Tumours of the Dura Mater, &c.," in the Glasgow Medical Journal, 1863.)

BLOOD-VESSELS OF THE BRAIN AND SPINAL CORD.

The origin and course of these vessels have already been described in the Section Angeiology. In passing to their distribution the several arteries, having passed across the arachnoid cavity enter the subarachnoid space and then divide and subdivide into branches, which, in their farther ramification in the nervous centres, are supported by the pia mater, and, it may be remarked, are more deeply placed in the various fissures and sulci than the small veins, which do not accompany the arteries, but pursue a different course and are seen upon the surface of the pia mater.

Moreover, it is to be observed, that whilst the main branches of the arteries are situated at the base of the brain, the principal veins tend

towards the upper surface of the hemispheres, where they enter the superior and inferior longitudinal sinuses: the veins of Galen, however, coming from the lateral ventricles and choroid plexuses, run backwards to the straight sinus.

SIZE AND WEIGHT OF THE ENCEPHALON.

In the following table illustrating the average weight of the adult male and female brain, the results obtained by Sims, Clendinning, Tiedemann, and J. Reid have been brought together in such a form as to exhibit in groups the most commonly prevailing weights; the numbers being also simplified by the omission of fractions. (Sims, "Medico-Chirurg. Trans.," vol. xix., pp. 353—7; Clendinning, "Medico-Chirurg. Trans.," vol. xxi., pp. 59—68; Tiedemann, "Das Hirn des Negers," Heidelberg, 1837, pp. 6, 7; Reid, "London and Edinburgh Monthly Journal of Medical Science," April, 1843, p. 298, &c.)

Table of the Average Weight of the Male and Female Brain.

Males, aged 21 years and upwards.

Weight in oz. avoirdupois.	Number of brains at each weight observed by: Clendinning.	Sims.	Tiedemann.	Reid.	Total number at each weight.	Classification into three groups, to show the *prevailing weight.*	
34	—	—	—	1	1	62 cases. from 34 oz. to 45 oz.	Difference 11.
37	—	2	—	—	2		
38	1	—	—	—	1		
39	—	3	—	1	4		
40	—	2	—	1	3		
41	—	3	—	2	5		
42	2	4	2	—	8		
43	—	6	2	3	11		
44	1	6	2	3	12		
45	6	8	—	1	15		
46	2	10	—	8	20	170 cases. from 46 oz. to 53 oz.	Difference 7.
47	2	6	—	10	18		
48	4	8	2	11	25		
49	3	2	2	12	19		
50	4	4	5	13	26		
51	3	3	2	19	27		
52	—	5	4	6	15		
53	4	2	4	10	20		
54	3	2	1	5	11	46 cases. from 54 oz. to 65 oz.	Difference 11.
55	—	—	2	4	6		
56	—	—	1	6	7		
57	—	—	—	2	2		
58	—	1	4	2	7		
59	—	1	2	3	6		
60	—	—	—	1	1		
61	—	—	2	1	3		
62	—	—	1	—	1		
63	—	—	—	1	1		
65	—	—	1	—	1		

Tot. 35+78+39+126=278.

Females, aged 21 years and upwards.

Weight in oz. avoirdupois.	Number of brains at each weight observed by: Clendinning.	Sims.	Tiedemann.	Reid.	Total number at each weight.	Classification into three groups, to show the *prevailing weight.*	
31	—	—	—	1	1	32 cases. from 31 oz. to 40 oz.	Difference 9.
32	—	1	—	—	1		
35	—	2	—	—	2		
36	—	4	—	—	4		
37	—	3	1	2	6		
38	2	—	—	—	2		
39	—	3	1	2	6		
40	3	3	—	4	10		
41	2	8	—	2	12	125 cases. from 41 oz. to 47 oz.	Difference 6.
42	3	6	1	3	13		
43	6	6	—	7	19		
44	5	4	—	13	22		
45	4	9	—	7	20		
46	2	9	2	12	25		
47	2	5	—	7	14		
48	—	2	2	2	6	34 cases. from 48 oz. to 56 oz.	Difference 8.
49	—	1	2	7	10		
50	—	2	1	4	7		
51	—	—	2	4	6		
52	1	—	—	—	1		
53	—	1	—	—	1		
54	—	2	—	—	2		
56	—	1	—	—	1		

Tot. 30+72+12+77=191.

According to this table, the maximum weight of the adult male brain, in a series of 278 cases, was 65 oz., and the minimum weight 34 oz. In a series of 191 cases, the maximum weight of the adult female brain was 56 oz., and the minimum 31 oz.; the difference between the extreme weights in the male subject being no less than 31 oz., and in the female 25 oz. By grouping the cases together in the manner indicated by brackets, it is shown that in a very large proportion the weight of the male brain

ranges between 46 oz. and 53 oz., and that of the female brain between 41 oz. and 47 oz. The *prevailing* weights of the adult male and female brain may therefore be said to range between those terms; and by taking the mean, an *average* weight is deduced of 49½ oz. for the male, and of 44 oz. for the female brain,—results which correspond closely with the statements generally received.

Although many female brains exceed in weight particular male brains, the general fact is sufficiently shown, that the adult male encephalon is heavier than that of the female,—the average difference being from 5 to 6 oz. This general superiority in absolute weight of the male over the female brain has been ascertained to exist at every period of life. In new-born infants the brain was found by Tiedemann to weigh on an average from 14¼ oz. to 15¾ oz. in the male, and from 10 oz. to 13¼ oz. in the female :—a fact of considerable interest in practical midwifery, for it has been shown that difficult labours occur in by far the largest number in the birth of male children. (Simpson, London and Edinburgh Monthly Journal of Medical Science, 1845.)

With the above results the observations of Peacock, published in the "Monthly Journ. of Med. Science" for 1847, and further observations by the same author in the "Journ. of the Pathol. Soc." in 1860, in the main agree.

The elaborate table compiled by Rudolph Wagner, and published in his "Vorstudien zu einer Wissensch. Morphol. und Physiol. des Menschl. Gehirns," 1860, containing 964 recorded cases in which the weight of the brain had been ascertained, may also be referred to as another recent useful contribution to the knowledge of this subject.

In illustration of the variation in the average weight of the brain at different ages the following table is given, deduced from the elaborate researches of Dr. Robert Boyd, in the examination of the brains of 2,086 sane persons of both sexes dying in the St. Marylebone Infirmary, and published in the Philos. Trans. for 1860. The weights are stated in oz. avoird. and decimal fractions of them.

Table of the Weight of the Brain of Males and Females at different Ages.

Periods of Life.	Males.				Females.			
	Number weighed.	Maximum.	Minimum.	Average.	Average.	Minimum.	Maximum.	Number weighed.
1 Children prematurely still-born	25	13.1	1.31	5.6	4.62	1.29	9.13	18
2 Children still-born at full period	43	22.	9.37	13.87	12.25	8.	15.12	31
3 New-born infants	42	15.37	6.	11.65	10.	1.75	16.	39
4 Under 3 months	16	32.75	10.5	17.42	15.94	11.	32.5	20
5 From 3 to 6 months	15	0.75	10.75	21.29	19.76	13.	34.75	25
6 From 6 to 12 months	46	36.13	17.75	27.42	25.7	16.37	39 13	40
7 From 1 to 2 years	34	41.25	23.25	33.25	29.8	18.	37.	33
8 From 2 to 4 years	29	50.5	30.5	38.71	34.97	27.75	44.5	29
9 From 4 to 7 years	27	49.5	24.5	40.23	40.11	34.75	48.25	19
10 From 7 to 14 years	22	57.25	39.25	45.96	40.78	34.	52.	18
11 From 14 to 20 years	19	58.5	36.5	48.54	43.94	37.5	52.	16
12 From 20 to 30 years	59	57.	39.25	47.9	43.7	35.75	55.25	72
13 From 30 to 40 years	110	60.75	33.75	48.2	43.09	33.25	53.	89
14 From 40 to 50 years	137	60.	33.75	47.75	42.81	27.5	52.5	106
15 From 50 to 60 years	119	59.	30.5	47.44	43.12	36.25	52.5	103
16 From 60 to 70 years	127	59.5	36.25	46.4	42.69	32.5	54.	149
17 From 70 to 80 years	104	55.25	37.75	45.5	41.27	29.25	49.5	148
18 Upwards of 80 years	24	53.75	41.	45.34	39.77	33.25	48.	77
Averages in Persons above 14 years	699	58.	36.1	47.1	42.5	33.1	52.1	760
Averages in Persons from 14 to 70 years	571	59.12	35.	47.7	43.15	33.8	53.15	535

Anatomists have differed considerably in their statements as to the period at which the brain attains its full size, and also as to the effect of old age in diminishing the weight of this organ. Sœmmerring held that the brain reached its full size as early

as the third year; the Wenzels and Sir W. Hamilton fixed the period about the seventh, and Tiedemann between the seventh and eighth years. Gall and Spurzheim were of opinion that the brain continued to grow until the fortieth year. The observations of Sims, Tiedemann and Reid appear to show that in both sexes the weight of the brain in general increases rapidly up to the seventh year, then more slowly to between sixteen and twenty, and again more slowly to between thirty-one and forty, at which time it reaches its maximum point. Beyond that period, there appears a slow, but progressive diminution in weight of about 1 oz. during each subsequent decennial period; thus confirming the opinion, that the brain diminishes in advanced life. According to Peacock, the maximum weight of the brain is attained between the ages of twenty and thirty years. The table of Boyd inserted above would appear to show a somewhat earlier period as that at which the maximum is reached in both sexes, and that the period of decline scarcely begins before sixty years. With this result the observations of Huschke, made upon the brains of 359 men and 245 women, in general agree. ("Schädel, Hirn und Seele des Menschen und der Thiere, &c.," 1854.)

All other circumstances being alike, the size of the brain appears to bear a general relation to the mental power of the individual,—although many instances occur in which this rule is not applicable. The brain of Cuvier weighed upwards of 64 oz., and there are other recorded examples of brains belonging to men of great talent which nearly equalled it in weight. (Emille Rousseau, "Maladie et autopsie de M. G. Cuvier," Lancette Française, Mai 26, 1832.) On the other hand, the brain in idiots is remarkably small. In three idiots, whose ages were sixteen, forty, and fifty years, Tiedemann found the weight of their respective brains to be 19$\frac{3}{4}$ oz., 25$\frac{3}{4}$ oz., and 22$\frac{1}{2}$ oz.; and Dr. Sims records the case of a female idiot twelve years old, whose brain weighed 27 oz. Allen Thomson has found the brain of a dwarfish idiot girl seventeen years of age to weigh 18$\frac{1}{4}$ oz. after preservation in alcohol.

The human brain is found to be absolutely heavier than that of all the lower animals except the elephant and whale. The brain of the elephant, according to Perrault, Moulins, and Sir A. Cooper, weighs between 8 and 10 lbs.; whilst that of the whale was found by Rudolphi, in a specimen 75 feet long, to weigh upwards of 5 lbs.

The *relative weight of the encephalon to the body* is liable to great variation; nevertheless, the facts to be gathered from the tables of Clendinning, Tiedemann, and Reid, furnish this interesting general result:—In a series of 81 males, the average proportion between the weight of the brain and that of the body, at the ages of twenty years and upwards, was found to be as 1 to 36·5; and in a series of 82 females, to be as 1 to 36·46. In these cases, the deaths were the result of more or less prolonged disease; but in 6 previously healthy males, who died suddenly from disease or accident, the average proportion was 1 to 40·8.

The proportionate weight of the brain to that of the body is much greater at birth than at any other period of life, being, according to Tiedemann, about 1 to 5·85 in the male, and about 1 to 6·5 in the female. From the observations already referred to, it further appears that the proportion diminishes gradually up to the tenth year, being then about 1 to 14. From the tenth to the twentieth year, the relative increase of the body is most striking, the ratio of the two being at the end of that period about 1 to 30. After the twentieth year, the general average of 1 to 36.5 prevails, with a further trifling decrease in advanced life.

Viewed in relation to the weight of his body, the brain of man may be stated generally to be heavier than the brains of the lower animals; but there are some exceptions to the rule, as in the case of certain species of small birds, in the smaller apes, and in some small rodent animals.

The attempts hitherto made to measure or estimate the relative proportions of the different convoluted parts of the cerebrum to each other and to the degree of intelligence, either more directly or by the cranioscopic methods, have as yet been attended with little success. The more recent researches of Rudolph Wagner, which have been farther prosecuted by his son, hold out some promise when fully carried out to afford more definite results.

These researches had for their object to institute an accurate comparison between the brains of certain persons of known intelligence, cultivation, and mental power, and those of persons of an ordinary or lower grade. As examples of brains of men of

superior intellect he selected those of Professor Gauss, a well-known mathematician of eminence, and Professor Fuchs, a clinical teacher; and as examples of brains of ordinary persons, those of a woman of 29 and a workman named Krebs, all of which he examined and measured with scrupulous care.

The general result of R. Wagner's researches upon these and other brains may be stated to be as follows:—1st. Although the greatest number of brains belonging to men of superior intellect are found to be heaviest or largest, yet there are so many instances in which the brains of such persons have not surpassed, or have even fallen below the average size of the brains of ordinary persons, that superiority of size cannot in the present state of our knowledge be regarded as a constant accompaniment of superiority of intellect, even when due regard has been paid to the comparative stature and other circumstances of the individuals.

2nd. It would appear that in the brains of certain persons of superior intellect, the cerebral convolutions have been found more numerous and more deeply divided than in those of persons of ordinary mental endowments and without cultivation. But numerous exceptional instances are also found of paucity of convolutions coincident with superior intellect, which make it impossible at present to deduce any certain conclusion with respect to the relation between the number or extent of the convolutions and the intellectual manifestations in different persons.

The careful measurement of all the convolutions and the intervening grooves in the four brains above mentioned has been carried out by the younger Wagner, and the tables and results of these measurements published by him as an appendix to his father's treatise. (Hermann Wagner, "Maasbestimmungen der Oberfläche des Grossen Gehirns," &c., Cassel und Göttingen, 1864.)

The following short table, extracted from Hermann Wagner's memoir, and simplified by the omission of small fractions and by the reduction of the measurements from square millimetres to English square inches, may give the reader some idea of the nature of the inquiry:—

Comparative measurement of the extent of surface of the Convolutions of the Cerebrum and its lobes.

	Surface of each lobe separately.				Free and deep surfaces of cerebrum.		Whole surface of Cerebrum.
	Frontal.	Parietal.	Occipital.	Temporal.	Free surface.	Deep or covered surface.	
1. Gauss	139.	70.6	59.4	68.4	112.8	228.2	341
2. Fuchs	143.4	69.5	59.	67.5	110.7	231.3	342
3. Woman	130.	65.	51.	66.8	107.5	209.9	317.5
4. Workman ...	113.2	62.3	50.5	62.	97.4	193.6	291.

WEIGHT OF THE SEVERAL PARTS OF THE ENCEPHALON.

As the result of observations made in reference to this subject, on the brains of 53 males and 34 females, between the ages of twenty-five and fifty-five, Dr. J. Reid has given the following table:—

	Males. oz.	drs.	Females. oz.	drs.	Difference. oz.	drs.
Average weight of cerebrum	43	15¾	38	12	5	3¾
" cerebellum	5	4	4	12¼	0	7¾
" pons and medulla oblongata .	0	15¾	1	0¼	0	0½
" entire encephalon . .	50	3½	44	8½	5	11

With these results the observations of Huschke derived from a special examination of the brains of 22 females, and 38 males, mainly agree.

From this it appears that the proportionate weight of the cerebellum to that of the cerebrum is, in the male, as 1 to $8\frac{1}{7}$, and in the female as 1 to $8\frac{1}{4}$. The cerebellum attains its maximum weight from the twenty-fifth to the fortieth year; but the increase in weight after the fourteenth year is shown to be relatively greater in the female than in the male. The whole cerebellum apart from the pons and medulla is heavier in the male; the lateral lobes of the cerebellum are also heavier in the male. In the male the vermiform process increases gradually from the twentieth to the fiftieth year; in the female it remains stationary during that period, and after the fiftieth year diminishes rapidly.

In the new-born infant the ratio of the weight of the cerebellum to that of the whole brain is strikingly different from that observed in the adult, being, according to Chaussier, between 1 to 13 and 1 to 26; by Cruvelhier it was found to be 1 to 20. Huschke found the weight of the cerebellum, medulla oblongata and pons together in the newborn infant, as compared with that of the brain, to be in the proportion of 1 to 15, and 1 to 13. In the adult, the proportions were 1 to 7, and 1 to 6.

In most mammalia, the cerebellum is found to be heavier in proportion to the cerebrum, than it is in the human subject; in other words, the cerebrum in man is larger in proportion to the cerebellum.

Sœmmerring pointed out the fact that the brain is larger in proportion to the nerves connected with it in man than in the lower animals.

A comparison of the width of the cerebrum with that of the medulla oblongata shows that the proportionate diameter of the brain to that of the medulla oblongata is greater in man than in any animal, except the dolphin, in which creature, however, it must be remembered that the cerebral lobes exhibit a disproportionate lateral development. The width of the cerebrum in man, as compared with that of the medulla oblongata at its base or broadest part, is about 7 to 1, while in many quadrupeds it is as 3 to 1 or even as 2 to 1.

WEIGHT OF THE SPINAL CORD.

Divested of its membranes and nerves, the spinal cord in the human subject weighs from 1 oz. to $1\frac{3}{4}$ oz., and therefore its proportion to the encephalon is about 1 to 33. Meckel states it as 1 to 40.

The disproportion between the brain and the spinal cord becomes less and less in the descending scale of vertebrata, until at length, in cold-blooded animals, the spinal cord becomes heavier than the brain. Thus, in the mouse, the weight of the brain, in proportion to that of the spinal cord, is as 4 to 1; in the pigeon, as $3\frac{1}{3}$ to 1; in the newt, only as $\frac{5}{9}$ to 1; and in the lamprey, as $\frac{1}{75}$ to 1.

In comparison with the size of the body, the spinal cord in man may be stated in general terms to be much smaller than it is in animals. In regard to the cold-blooded animals, to birds, and to small mammalia, this has been actually demonstrated, but not in reference to the larger mammalia.

R. Wagner states, as follows, the proportion of the weight of the spinal marrow taken as 1 to the encephalon and its parts—

a, to the nerve roots	: : 1 : 0·53
b, to the medulla and pons	: : 1 : 1·
c, to the cerebellum	: : 1 : 5·18
d, to the cerebrum	: : 1 : 42·78
e, to the encephalon	: : 1 : 48·96

SPECIFIC GRAVITY OF THE ENCEPHALON.

The specific gravity of different parts of the encephalon has of late attracted some attention from its having been observed that it varies to some extent in different kinds of disease. From the researches of Bucknill, Sankey, Aitken, and Peacock it appears that the average specific gravity of the whole encephalon is about 1036, that of the grey matter 1034, and that of the white 1040. There are also considerable differences in the specific gravity of some of the internal parts. (William Aitken, "The Science and Practice of Medicine," 1865, vol. 2, p. 265: J. C. Bucknill in "The Lancet," 1852: Sankey, in the "Brit. and For. Med. Chir. Review," 1853: Thos. B. Peacock, in the Trans. of the Pathol. Soc. of London, 1861-2.)

DEVELOPMENT OF THE CEREBRO-SPINAL AXIS.

The cerebro-spinal axis is formed from a superficial deposit of blastema, which occupies the whole width of the dorsal furrow, that elongated depression whose margins come together to complete the walls of the cranio-vertebral cavity (p. 15). This layer of blastema increases in thickness in each lateral half, while in the middle line—the primitive groove—it remains thin and depressed. The thin middle portion is that which forms in the spinal cord the anterior commissure. At the same time that the walls of the cranio-vertebral cavity are completed behind, the lateral margins of the cerebro-spinal axis are also bent backwards and meet together, so as to form a tube, and this line of junction is the rudiment, in the spinal cord, of the posterior commissure, while the space within the cylinder is the central canal. The closure of the canal first takes place in the cervical region, and subsequently proceeds thence backwards in the dorsal, lumbar, and sacral regions.

Fig. 386.

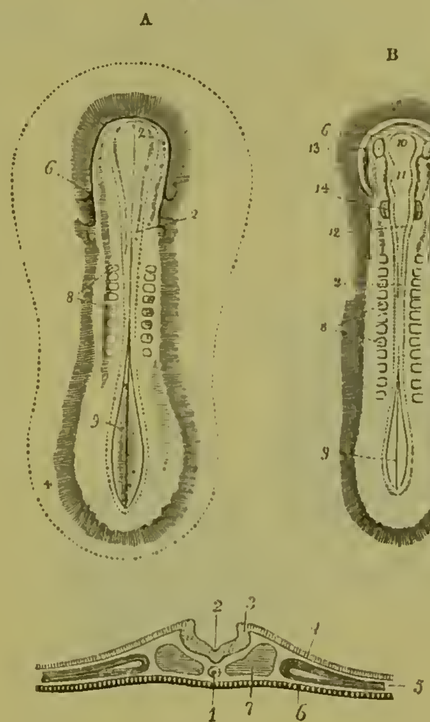


Fig. 386.—Primitive form of the Cerebro-Spinal Axis in the Embryo of the Bird. Magnified.

A and B (from Reichert) outlines of the dorsal aspect of the embryo bird at twenty-four and thirty-six hours of incubation. In A, the sides of the primitive groove have united to a great extent and converted it into a canal, dilated at the cephalic extremity, 2; 6, the cephalic fold of the germinal membrane; 8, the primordial vertebral masses; 9, the unclosed lumbar part of the vertebral groove. In B, 10, 11, and 12 indicate the partial division of the cephalic portion of the tube into the three primary vesicles; 13, the rudiment of the eye; 14, that of the ear.

C, represents a transverse section of the body of the embryo previous to the closure of the vertebral groove. 1, chorda dorsalis; 2, primitive vertebral groove; 2 to 3, medullary plates continuous at 3, with 4, the corneous layer of the blastoderm; 5, the ventral plates of the middle layer; 6, the lowest or epithelial layer; 7, the primordial vertebral masses.

Fig. 387.

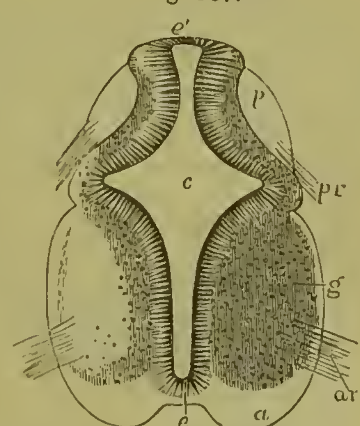


Fig. 387.—Transverse Section of the Cervical Part of the Spinal Cord of a Human Embryo of Six Weeks (from Kölliker). $\frac{30}{1}$

This and the following figure are only sketched, the white matter and a part of the grey not being shaded in. *c*, central canal; *c*, its epithelial lining; at *e* (inferiorly), the part which becomes the anterior commissure; at *e′* (superiorly) the part which becomes the posterior commissure; *a*, the white substance of the anterior columns, beginning to be separated from the grey matter of the interior, and extending round into the lateral column, where it is crossed by the line from *g*, which points to the grey substance; *p*, posterior column; *a r*, anterior roots; *p r*, posterior roots.

The SPINAL CORD has been found by Kölliker already in the form of a cylinder in the cervical region of an embryo four weeks old. Ununited borders have been seen by Tiedemann in the ninth week towards the lower end of the cord, the perfect closing of the furrow being delayed in that part, which is slightly enlarged and presents a longitudinal median slit, analogous to the rhomboidal sinus in birds.

The *anterior fissure* of the cord is developed very early, and contains even at first a process of the pia mater.

The *cervical* and *lumbar enlargements* opposite the attachments of the brachial and crural nerves, appear at the end of the third month: in these situations the central canal, at that time not filled up, is somewhat larger than elsewhere.

Fig. 388.

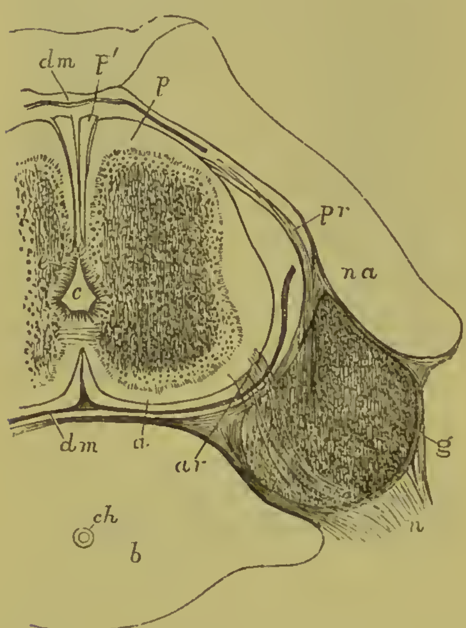


Fig. 388.—TRANSVERSE SECTION OF HALF THE CARTILAGINOUS VERTEBRAL COLUMN AND THE SPINAL CORD IN THE CERVICAL PART OF A HUMAN EMBRYO OF FROM NINE TO TEN WEEKS (from Kölliker). $\frac{10}{1}$

c, central canal lined with epithelium; *a*, anterior column; *p*, posterior column; *p'*, band of Goll; *g*, ganglion of the posterior root; *p r*, posterior root; *a r*, anterior root passing over the ganglion; *d m*, dura matral sheath, omitted near *p r*, to show the posterior roots; *b*, body of the vertebra; *c h*, chorda dorsalis; *n a*, neural arch of the vertebra.

At first the cord occupies the whole length of the vertebral canal, so that there is no cauda equina. In the fourth month, the vertebræ begin to grow more rapidly than the cord, and the latter seems as it were to have retired up into the canal, and the elongation of the roots of the nerves which gives rise to the *cauda equina* is commenced. At the ninth month, the lower end of the cord is opposite the third lumbar vertebra.

In textural composition the spinal cord consists at first, after the completion of its cylindrical form, entirely of uniform-looking cells. These separate into two layers, the inner of which forms the epithelium and surrounding connective tissue, or neuroglia of the central canal, while the outer forms the grey substance of the cord. The white substance appears later than the grey, forming a layer external to it, and separated from an early period into an antero-lateral and a posterior column on each side. At a somewhat later period the white mass of these columns, increasing greatly in size, gives rise to the formation and gradually increasing depth of the anterior and posterior median fissures. At the same time, however, the lateral masses of grey substance also undergo extension in the parts named the cornua. It would appear that the integral nerve fibres are at first developed from radiating processes which proceed from the cells of the grey substance. (Kölliker, Entwicklungs-geschichte; Lockhart Clarke, in the Phil. Trans. 1862; Bidder und Kupfer, Untersuch. üb. d. Rückenmark, Leipz. 1857.)

It may also be mentioned, that according to Remak and Kölliker, the roots of the spinal nerves and the ganglion are at first unconnected with the cord. The mass of blastema forming the ganglion first becomes apparent, and from this the posterior root seems to grow towards, and later to become attached to the cord, while the anterior roots seem to extend outwards from the cord and to unite themselves later with the nerve.

The central canal is at first nearly cylindrical; it then becomes flattened at the sides, projecting deeply backwards and forwards. Between the eighth and tenth weeks it is greatly narrowed, and subsequently, being more and more confined to the centre, it ultimately diminishes to a small tube. The epithelial cells which line it from the first are long or columnar, and they retain this form in the adult.

THE ENCEPHALON.

The brain is originally not to be distinguished from the spinal cord, being in fact the anterior portion of the medullary tube. It is soon altered in form, however, by the expansion of its walls in certain parts, while others enlarge in a less degree, and it then presents the appearance of a series of three cerebral vesicles, usually designated by embryologists the *primary cerebral vesicles.*

Fig. 389.

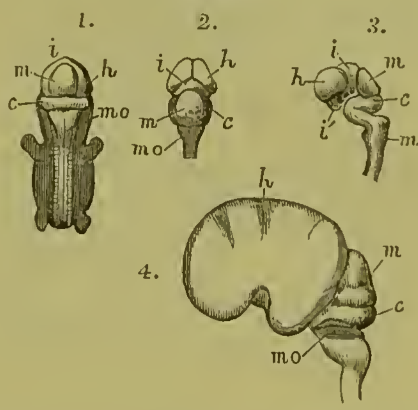


Fig. 389.—Sketches of the Primitive Parts of the Human Brain (from Kölliker).

1, 2, and 3 are from a human embryo of about seven weeks. 1, view of the whole embryo from behind, the brain and spinal cord exposed; 2, the posterior, and 3, the lateral view of the brain removed from the body; *h*, the anterior part of the first primary vesicle or cerebral hemisphere (prosencephalon); *i*, the posterior part of the same vesicle (diencephalon); *i'*, the lower part of the same; *m*, the middle primary vesicle (mesencephalon); *c*, the cerebellum or upper part of the third primary vesicle (epencephalon); *m o*, the lower part of the third primary vesicle or medulla oblongata. The figure 3 illustrates the several curves which take place in the development of the parts from the primitive medullary tube. In 4, a lateral view is given of the brain of a human embryo of three months: the enlargement of the cerebral hemisphere has covered in the optic thalami, leaving the tubercula quadrigemina, *m*, apparent.

The changes which take place in the growth of the brain were first elaborately described by Tiedemann; they have been investigated by Von Baer, Bischoff, Remak, Kölliker, and others, and have recently received additional elucidation from the researches of Reichert. (Tiedemann, "Anatomie und Bildungs-geschichte des Gehirns," Nüremberg, 1816; Reichert, "Bau des Menschlichen Gehirns," Leipzig, 1861; F. Schmidt, "Beitrage z. Entwick. des Gehirns," in Zeitschr. f. Wissen. Zool. 1862; Kölliker, Entwicklungsgeschichte, 1861.)

Development of the primary vesicles.—The anterior, or *first vesicle*, is the part from which are developed the third ventricle, the optic thalami, the corpora striata, and the cerebral hemispheres.

The middle or *second vesicle*, forms the corpora quadrigemina above, and the crura cerebri below,—its cavity remaining as the Sylvian aqueduct.

The posterior or *third vesicle* continues incomplete above for some time, in so far as relates to its nervous substance. At length its anterior portion is closed over and forms the cerebellum above, whilst in its under part the pons Varolii is produced. The posterior portion, on the other hand, continues open on its dorsal aspect, and forms the medulla oblongata and fourth ventricle.

Fig. 390.

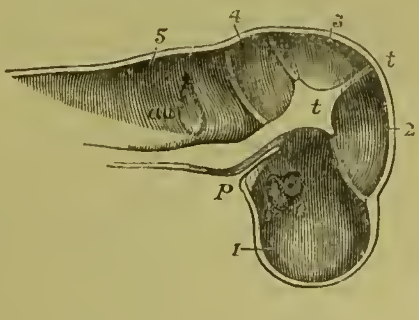


Fig. 390.—Longitudinal Section of the Cranial Cavity of the Human Embryo at four weeks (from Kölliker). $\frac{10}{1}$

1, 2, 3, 4, and 5, mark the depressions in the cranial wall which contain respectively the cerebral hemispheres, the thalami, the corpora quadrigemina, the cerebellum, and the medulla oblongata; in 1, at o, the depression of the eye, and at o', the optic nerve is seen; in 5, at *a u*, the primary auditory vesicle; *p*, process from the pharynx, supposed by Rathke to be connected with the formation of the pituitary body or hypophysis cerebri; *t*, *t*, middle cranial septum or tentorium.

These three vesicles, at first arranged in a straight line one before the other, soon

alter their position, in correspondence with the curving downwards of the cephalic end of the embryo. Thus, at the seventh week, there is an angular bend forwards between the hindmost vesicle and the rudimentary spinal cord, the projecting angle (backwards) being named the cervical tuberosity. Another bend, but in the opposite direction, exists between that part of the third vesicle which forms the medulla oblongata, and that which gives rise to the cerebellum. Lastly, a third angle is produced by a bend forwards and downwards in the region of the middle vesicle, from which the corpora quadrigemina are developed, and which forms, at this period, the highest part of the encephalon; whilst the anterior, or first vesicle, is bent nearly at a right angle downwards.

Fig. 391.

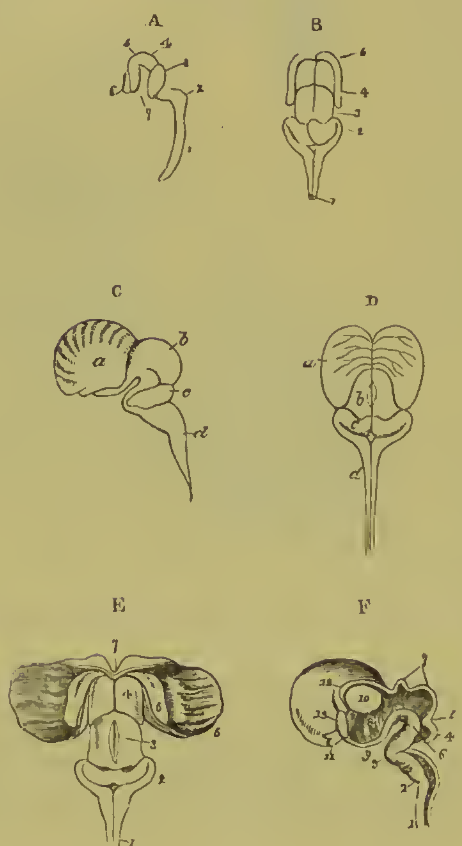


Fig. 391.—Sketches of the early form of the parts of the Cerebro-Spinal Axis in the Human Embryo (after Tiedemann).

A, at the seventh week, lateral view; 1, spinal cord; 2, medulla oblongata; 3, cerebellum; 4, middle vesicle or corpora quadrigemina; 5, 6, 7, first vesicle. B, at the ninth week, posterior view; 1, medulla oblongata; 2, cerebellum; 3, corpora quadrigemina; 4, 5, thalami optici and cerebral hemispheres. C and D, lateral and posterior views of the brain of the human embryo at twelve weeks. *a*, cerebrum; *b*, corpora quadrigemina; *c*, cerebellum; *d*, medulla oblongata; the thalami are now covered by the enlarged hemispheres. E, posterior view of the same brain dissected to show the deeper parts. 1, medulla oblongata; 2, cerebellum; 3, corpora quadrigemina; 4, thalami optici; 5, the hemisphere turned aside; 6, the corpus striatum embedded in the hemisphere; 7, the commencement of the corpus callosum. F, the inner side of the right half of the same brain separated by a vertical median section, showing the central or ventricular cavity. 1, 2, the spinal cord and medulla oblongata, still hollow; 3, bend at which the pons Varolii is formed; 4, cerebellum; 5, lamina (superior cerebellar peduncles) passing up to the corpora quadrigemina; 6, crura cerebri; 7, corpora quadrigemina, still hollow; 8, third ventricle; 9, infundibulum; 10, thalamus, now solid; 11, optic nerve; 12, cleft leading into the lateral ventricle; 13, commencing corpus callosum.

At an early period of the development of the brain, the anterior primary vesicle undergoes a peculiar change, by which two sets of parts are originated, the first of which corresponds to the cerebral hemispheres, the second to the thalami optici; the middle vesicle remaining single, giving rise to the corpora quadrigemina; and the posterior vesicle, like the first, but at a somewhat later period, serves as the basis of the rudiments of two parts, viz., the cerebellum and the medulla oblongata. Thus, out of the three primary vesicles five fundamental parts of the encephalon are formed.

The following tabular statement may serve as a synoptical view of the relation

subsisting between the primary encephalic vesicles, the five fundamental parts, and the principal permanent structures of the brain :—

I. Anterior primary Vesicle,	1. Prosencephalon.*	Cerebral Hemispheres, Corpus Callosum, Corpora Striata, Fornix, Lateral Ventricles, Olfactory nerve.
	2. Diencephalon.	Thalami Optici, Pineal gland, Pituitary body, Third Ventricle, Optic nerve.
II. Middle primary Vesicle,	3. Mesencephalon.	Crura Cerebri, Corpora Quadrigemina, Aqueduct of Sylvius.
III. Posterior primary Vesicle,	4. Epencephalon.	Cerebellum, Pons Varolii, anterior part of the Fourth Ventricle.
	5. Metencephalon.	Medulla Oblongata, Fourth Ventricle, Auditory nerve.

At a later period of development, the anterior part of the first vesicle, which, as stated above, represents the cerebral hemispheres, increases greatly in size upwards and backwards, and gradually covers the parts situated behind it; first the thalami, then the corpora quadrigemina, and lastly the cerebellum.

On laying open the rudimentary encephalon, two tracts of nervous matter are seen to be prolonged upwards from the spinal cord upon the floor of the cephalic vesicles: these tracts, which are doubtless connected with the anterior and lateral parts of the cord, are the rudiments of the *crura cerebri* and corresponding columns of the medulla oblongata.

Farther development of the primary vesicles.—The *third vesicle*—The posterior portion of this vesicle, corresponding with the *medulla oblongata*, is never closed above by nervous matter. The open part of the medullary tube constitutes the floor of the *fourth ventricle*, which communicates below with the canal of the spinal cord, at the place where the calamus scriptorius is eventually formed.

The three constituent parts of the medulla oblongata begin to be distinguished about the third month; first, the *restiform* bodies which are connected with the commencing cerebellum, and afterwards the anterior pyramids and olives. The *anterior pyramids* become prominent on the surface and distinctly defined in the fifth month; and by this time also their decussation is evident. The *olivary* fasciculi are early distinguishable, but the proper *olivary body*, or tubercle, does not appear till about the sixth month. The *fasciolæ cinereæ* of the fourth ventricle can be seen at the fourth or fifth month, but the *white striæ* not until after birth.

The anterior part of the third vesicle is soon closed above by nervous substance, and forms the commencing *cerebellum*. This part exists about the end of the second month, as a delicate medullary lamina, forming an arch behind the corpora quadrigemina across the widely-open primitive medullary tube.

According to Bischoff, the cerebellum does not commence, as was previously supposed, by two lateral plates which grow up and meet each other in the middle line; but a continuous deposit of nervous substance takes place across this part of the medullary tube, and closes it in at once. This layer of nervous matter, which is soon connected with the corpora restiformia, or inferior peduncles, increases gradually up to the fourth month, at which time there may be seen on its under surface the commencing *corpus dentatum*. In the fifth month a division into five *lobes* has taken place; at the sixth, these lobes send out *folia*, which are at first simple, but afterwards become subdivided. Moreover, the *hemispheres* of the cerebellum are now relatively larger than its median portion, or *worm*. In the seventh month the organ is more complete, and the *flocculus* and *posterior velum*, with the other parts of the inferior vermiform process, are now distinguishable, except the *amygdalæ*, which are later in their appearance.

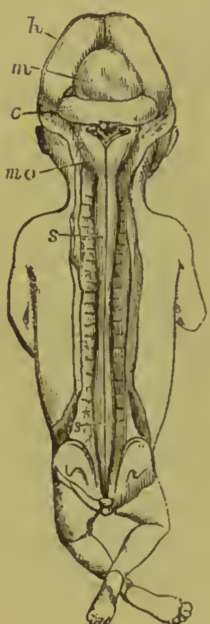
Of the *peduncles* of the cerebellum, the *inferior* pair (corpora restiformia) are the first seen—viz., about the third month; the *middle* peduncles are perceptible in the fourth month; and at the fifth, the *superior* peduncles and the Vieussenian valve.

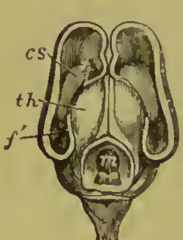
* This and the four following terms are adopted as applicable to the principal secondary divisions of the primordial medullary tube, and as corresponding to the commonly received names of the German embryologists, viz., Vorderhirn, Twischenhirn, Mittelhirn, Hinterhirn, and Nachhirn; or their less used English translations, viz.,—forebrain, interbrain, midbrain, hindbrain, and afterbrain.

The *pons Varolii* is formed, as it were, by the fibres from the hemispheres of the cerebellum embracing the pyramidal and olivary fasciculi of the medulla oblongata. According to Baer, the bend which takes place at this part of the encephalon thrusts down a mass of nervous substance before any fibres can be seen; and in this substance transverse fibres, continuous with those of the cerebellum, are afterwards developed. From its relation to the cerebellar hemispheres the pons keeps pace with them in its growth; and, in conformity with this relation, its transverse fibres are few, or entirely wanting, in those animals in which there is a corresponding deficiency or absence of the lateral parts of the cerebellum.

Fig. 392.

A.





B.

Fig. 392 A.—Brain and Spinal Cord exposed from behind in a Fœtus of three months (from Kölliker).

h, the hemispheres; *m*, the mesencephalic vesicle or corpora quadrigemina; *c*, the cerebellum; below this are the medulla oblongata, *mo*, and fourth ventricle, with remains of the membrana obturatoria. The spinal cord, *s*, extends to the lower end of the sacral canal and presents the brachial and crural enlargements.

Fig. 393 B.—Upper View of the Brain of a three months' Fœtus, in which the Hemispheres have been divided and turned aside, and the Vesicle of the Mesencephalon (Corpora Quadrigemina) opened (from Kölliker).

f, anterior part of the great arch of the hemispheres over the cerebral fissure; *f'*, posterior part descending into the cornu ammonis; *c s*, corpus striatum; *t h*, thalamus opticus; *m*, in the floor of the opened vesicle of the mesencephalon, which is still hollow.

The *second*, or *middle vesicle*.—The *corpora quadrigemina* are formed in the upper part of the middle cephalic vesicle; the hollow in the interior of which, communicates with those of the first and third vesicles. The corpora quadrigemina, in the early condition of the human embryo, are of great proportionate volume, in harmony with what is seen in the lower vertebrata; but subsequently they do not grow so fast as the anterior parts of the encephalon, and are therefore soon overlaid by the cerebral hemispheres, which at the sixth month cover them in completely. Moreover, they become gradually solid, by the deposition of matter within them; and as, in the meantime, the *cerebral peduncles* are increasing rapidly in size in the floor of this middle cephalic vesicle, the cavity in its interior is quickly filled up, with the exception of the narrow passage named the *Sylvian aqueduct*. The fillet is distinguishable in the fourth month. The corpora quadrigemina of the two sides are not marked off from each other by a vertical median groove until about the sixth month; and the transverse depression separating the anterior and posterior pairs is first seen about the seventh month of intra-uterine life.

The *first*, or *anterior vesicle*.—This vesicle, very soon after its formation, exhibits two lateral outgrowths—the *optic vesicles*,—destined to form the fundamental parts of the organs of vision. Each of these soon becomes separated from the parent vesicle by a constricted part, which forms the optic nerve and tract. The first vesicle has usually been described as dividing into two portions—viz., a posterior, which is developed into the optic thalami and third ventricle, and an anterior, which forms the principal mass of the cerebral hemispheres, including the corpora striata. Reichert, however, has pointed out that the hemispheres and corpora striata are developed from the sides of the fore part of the vesicle, and become distinguished from it by a constriction similarly as the optic vesicles had previously been, and that there is left between the *hemisphere-vesicles* of opposite sides a wedge-shaped interval, which forms the third ventricle. He points out that the terminal extremity of the cerebro-spinal tube is at the tip of this wedge, and is placed immediately in front of the optic commissure, at the lamina cinerea; and that therefore the infundibulum is not that

extremity, as had been previously supposed by Baer, but is an expansion of the vesicle downwards, in similar fashion as there is an expansion of it upwards in the region of the pineal body.

The *pituitary body* was asserted by Rathke to be derived from a prolongation upwards of the mucous membrane of the pharynx into the base of the skull between the trabeculæ. It appears, however, from the researches of Reichert and Bidder, that the base of the skull is never imperfect in this region. Reichert suggested that the pituitary body might be derived from the extremity of the chorda dorsalis, but is now rather inclined to think that it is a development of the pia mater.

Fig. 393.

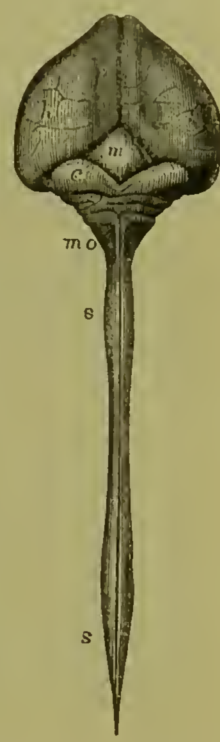


Fig. 393.—Brain and Spinal Cord of a Fœtus of four months, seen from behind (from Kölliker).

h, hemispheres of the cerebrum; *m*, corpora quadrigemina or mesencephalon; *c*, cerebellum; *m o*, medulla oblongata, the fourth ventricle being overlapped by the cerebellum; *s*, *s*, the spinal cord with its brachial and crural enlargements.

The *pineal gland*, according to Baer, is developed from the back part of the thalami, where those bodies continue joined together; but it is suggested by Bischoff that its development may be rather connected with the pia mater. It was not seen by Tiedemann until the fourth month: subsequently its growth is very slow; and it at first contains no gritty deposit: this, however, was found by Sömmerring at birth.

The two *optic thalami*, formed from the posterior part of the anterior vesicle, consist at first of a single hollow sac of nervous matter, the cavity of which communicates in front with the interior of the commencing cerebral hemispheres, and behind with that of the middle cephalic vesicle (corpora quadrigemina). Soon, however, by means of a deposit taking place in their interior

Fig. 394.

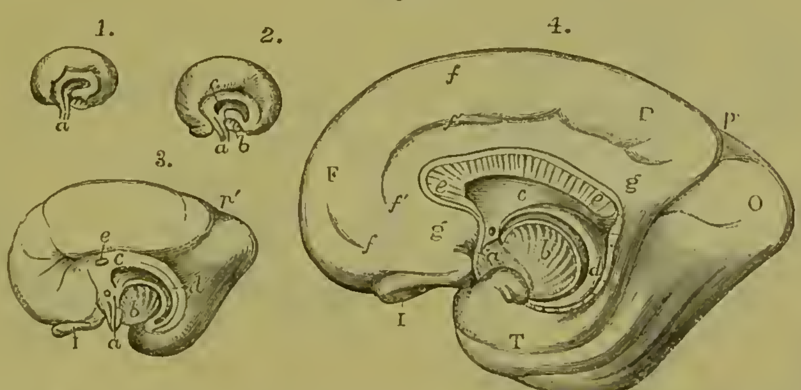


Fig. 394.—Semidiagrammatic Views of the Inner Surface of the Right Cerebral Hemisphere of the Fœtal Brain at various stages of development (from Schmidt).

1, 2, and 3, are from fœtuses of the respective ages of eight, ten, and sixteen weeks; 4, from a fœtus of six months. *a*, lamina terminalis or part of the first primary vesicle which adheres to the sella turcica; *b*, section of the cerebral peduncle as it passes into the thalamus and corpus striatum; the arched line which surrounds this bounds the great cerebral fissure; *c*, anterior part of the fornix and the septum lucidum; *d*, inner part of the arch of the cerebrum, afterwards the hippocampus major and posterior part of the fornix; *e*, corpus callosum, very short in 3, elongated backwards in 4; in 4, *f*, the superior marginal convolution; *f′*, fronto-parietal fissure; *g*, gyrus fornicatus; *p′*, the internal vertical fissure descending to meet the fissure of the hippocampus; I, olfactory bulb; F, P, O, T, frontal, parietal, occipital and temporal lobes.

behind, below, and at the sides, the thalami become solid, and at the same time a cleft or fissure appears between them above, and penetrates down to the internal cavity, which continues open at the back part opposite the entrance of the Sylvian aqueduct. This cleft or fissure, is the *third ventricle*. Behind, the two thalami continue united by the *posterior commissure*, which is distinguishable about the end of the third month, and also by the *peduncles of the pineal gland*. The *soft commissure* could not be detected by Tiedemann until the ninth month; but its apparent absence at earlier dates may perhaps be attributed to the effects of laceration.

At an early period the *optic tracts* may be recognised as hollow prolongations from the outer part of the wall of the thalami while they are still vesicular. At the fourth month these tracts are distinctly formed.

The *hemisphere-vesicle* becomes divisible into two parts: one of these is the part which from the interior appears as the corpus striatum, and from the exterior as the island of Reil, or central lobe; the other forms the expanded or covering portion of the hemisphere, and is designated by Reichert, the *mantle*. The aperture existing at the constricted neck of the hemisphere vesicle, Schmidt and Reichert have recognised as the foramen of Monro.

The *corpora striata*, it will be observed, have a very different origin from the optic thalami; for, while the optic thalami are formed by thickening of the circumferential wall of a part of the first cerebral vesicle, and thus correspond in their origin with all the parts of the encephalon behind them, which are likewise derived from portions of the cerebro-spinal tube, the corpora striata appear as thickenings of the floor of the hemisphere-vesicles, which are lateral offshoots from the original cerebro-spinal tube. On this account Reichert considers the brain primarily divisible into the stem, which comprises the whole encephalon forwards to the tænia semicircularis, and the hemisphere-vesicles, which include the corpora striata and hemispheres.

The cerebral hemispheres enlarging, and having their walls increased in thickness, form, during the fourth month (Tiedemann), two smooth shell-like lamellæ, which include the cavities afterwards named the *lateral ventricles*, and the parts contained within them. Following out the subsequent changes affecting the exterior of the cerebral hemispheres, it is found that about the fourth month the first traces of some of the *convolutions* appear, the intermediate *sulci* commencing only as very slight

Fig. 395.

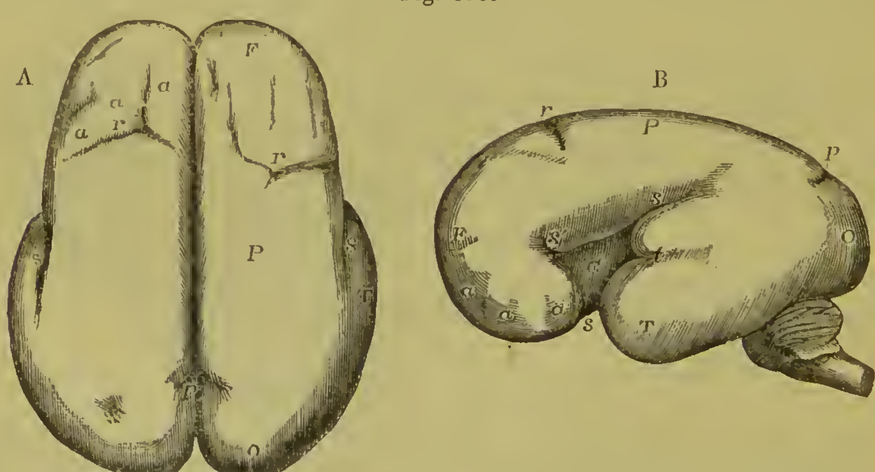


Fig. 395.—The Surface of the Fœtal Brain at Six Months (from R. Wagner).

This figure is intended to show the commencement of the formation of the principal fissures and convolutions. A, from above; B, from the left side. F, frontal lobe; P, parietal; O, occipital; T, temporal; *a*, *a*, *a*, slight appearance of the several frontal convolutions; *s*, the Sylvian fissure; *s'*, its anterior division; within it, C, the central lobe or convolutions of the island; *r*, fissure of Rolando; *p*, the vertical fissure (external part); *t*, the parallel fissure.

depressions on the hitherto smooth surface. Though the hemispheres continue to grow quickly upwards and backwards, the convolutions at first become distinct by

comparatively slow degrees; but towards the seventh and eighth months they are developed with great rapidity, and at the beginning of the last month of intra-uterine life, all the principal ones are marked out.

The *Sylvian fissure*, which afterwards separates the anterior from the middle lobe of each hemisphere, begins as a depression or cleft between them about the fourth month, and, after the great longitudinal, is the first of the fissures to make its appearance. It is followed by the fissure of Rolando, and the vertical fissure, and somewhat later by the internal fronto-parietal fissure. After this, the various subordinate fissures dividing the convolutions gradually make their appearance. By the end of the third month the hemispheres have extended so far backwards as to cover the thalami; at the fourth, they reach the corpora quadrigemina; at the sixth, they cover those bodies and great part of the cerebellum, beyond which they project still further backwards by the end of the seventh month.

During the growth of the hemisphere the aperture of the foramen of Monro is extended backwards; the arched margin of this opening is curved downwards at its extremities, and forms anteriorly the fornix, and posteriorly the corpus fimbriatum and hippocampus major; above the margin a part of the wall of each hemisphere comes into contact with its fellow, and in the lower part forms the septum lucidum, while above this the hemispheres are united by the development of the great commissure, the corpus callosum.

The *corpus callosum* is described by Tiedemann as being first seen about the end of the third month, as a narrow vertical band, extending across between the forepart of the two hemispheres, and subsequently growing backwards. With this view the observations of Schmidt coincide. Reichert, however, maintains that the commissural structure seen at the forepart of the hemispheres is the anterior white commissure, and that the corpus callosum appears in its whole extent at once.

The *corpora albicantia* at first form a single mass: so also do the *anterior pillars* of the fornix, which are distinguished before the posterior pillars. The *posterior pillars* are not seen until the fourth or fifth month. At that period the *hippocampus minor* is also discernible.

Fig. 396.

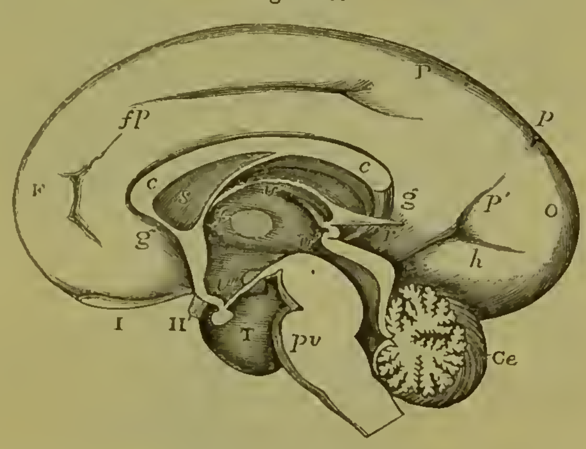


Fig. 396.—View of the Inner Surface of the right half of the Fœtal Brain of about six months (from Reichert).

F, frontal lobe; P, parietal; O, occipital; T, temporal; I, olfactory bulb; II, right optic nerve; *fp*, fronto-parietal fissure; *p*, vertical fissure; *p'*, internal vertical fissure; *h*, hippocampal fissure; *g*, gyrus fornicatus; *c*, *c*, corpus callosum; *s*, septum lucidum; *f*, placed between the middle commissure and the foramen of Monro; *v*, in the upper part of the third ventricle immediately below the velum interpositum and fornix; *v'*, in the back part of the third ventricle below the pineal gland, and pointing by a line to the aqueduct of Sylvius; *v''*, in the lower part of the third ventricle above the infundibulum; *r*, recessus pinealis passing backwards from the tela choroidea; *p v*, pons Varolii; *Ce*, cerebellum.

MEMBRANES OF THE ENCEPHALON.

It is remarked by Bischoff, that the pia mater and arachnoid are formed by the separation of the outer layer of the primitive cephalic mass; and thus, that the *pia mater* does not send inwards processes into the fissures or sulci, nor into the ventricular cavities; but that every part of this vascular membrane, including the *choroid plexuses* and *velum interpositum*, is formed in its proper position in connection with the nervous matter. The dura mater, on the other hand, is developed from the inner surface of the dorsal plates.

The pia mater and dura mater have both been detected about the seventh or eighth week, at which period the tentorium cerebelli exists. At the third month, the falx cerebri, with the longitudinal and lateral sinuses, are perceptible; and the choroid plexuses of both the lateral and fourth ventricles are distinguishable. No trace of arachnoid, however, can be seen until the fifth month.

II. THE CEREBRO-SPINAL NERVES.

The nerves directly connected with the great cerebro-spinal centre constitute a series of symmetrical pairs, the number of which has been variously estimated from forty to forty-three. Of these nerves, when estimated at the smaller number, nine issue from the cranium through different foramina or apertures in its base, and are thence strictly named *cranial.* The tenth nerve passes out between the occipital bone and the first vertebra, and the remaining thirty nerves all issue below the corresponding vertebral pieces of the spine. To the whole series of thirty-one nerves the name of *spinal* is usually given.

A.—CRANIAL NERVES.

The cranial nerves, besides being named numerically, according to the relative position of the apertures for their exit from the cranium, have likewise been distinguished by other names, according to the place or mode of their distribution, and according to their functions or other circumstances.

The number of the cranial nerves has been variously stated as nine or as twelve by different anatomists; the difference consisting mainly in this, that, under one system, the nerves which enter the internal auditory meatus, and those which pass through the jugular foramen, are in each case considered a single pair (seventh and eighth) divisible into parts; while under another system each of the nerves is held to constitute a distinct pair. The following table presents a synoptical view of the cranial nerves under these two modes of enumeration, as in the respective systems of Willis and of Sömmerring:—

Willis.*		Sœmmerring.	
First pair of nerves		First pair of nerves	Olfactory nerves.
Second ,,		Second ,,	Optic.
Third ,,		Third ,,	Oculo motor.
Fourth ,,		Fourth ,,	Pathetic or trochlear.
Fifth ,,		Fifth ,,	Trifacial or trigeminal.
Sixth ,,		Sixth ,,	Abducent ocular.
Seventh ,,	nervus durus.	Seventh ,,	Facial motor.
	n. mollis	Eighth ,,	Auditory.
Eighth ,,	n. vagus	Ninth ,,	Glosso-pharyngeal.
		Tenth ,,	Pneumo-gastric.
	accessorius	Eleventh ,,	Spinal accessory.
Ninth ,,		Twelfth ,,	Hypoglossal or lingual motor.

The arrangement of Sömmerring is the preferable one, as being the simplest and most natural; for each of the parts included in the seventh and eighth pairs of Willis is really a distinct nerve. But as the plan of Willis is still in more general use, it will most conveniently be followed here. The cranial nerves will therefore, when not otherwise designated, be referred to as consisting of nine pairs.

* Willis described the glosso-pharyngeal nerve as a branch of the vagus, and included the suboccipital nerve as a tenth among the cranial nerves.

CONNECTIONS OF THE CRANIAL NERVES WITH THE ENCEPHALON.

The roots of the cranial nerves may be traced for some depth into the substance of the encephalon, a circumstance which has led to the distinction of the *deep* or *real* origin, and the *superficial* or *apparent* origin, by which latter is understood the place at which the nerve appears to be attached to the surface of the encephalon. The superficial origin of these nerves is quite obvious, but their deeper connection is, in most cases, still a matter of some uncertainty.

Fig. 397.

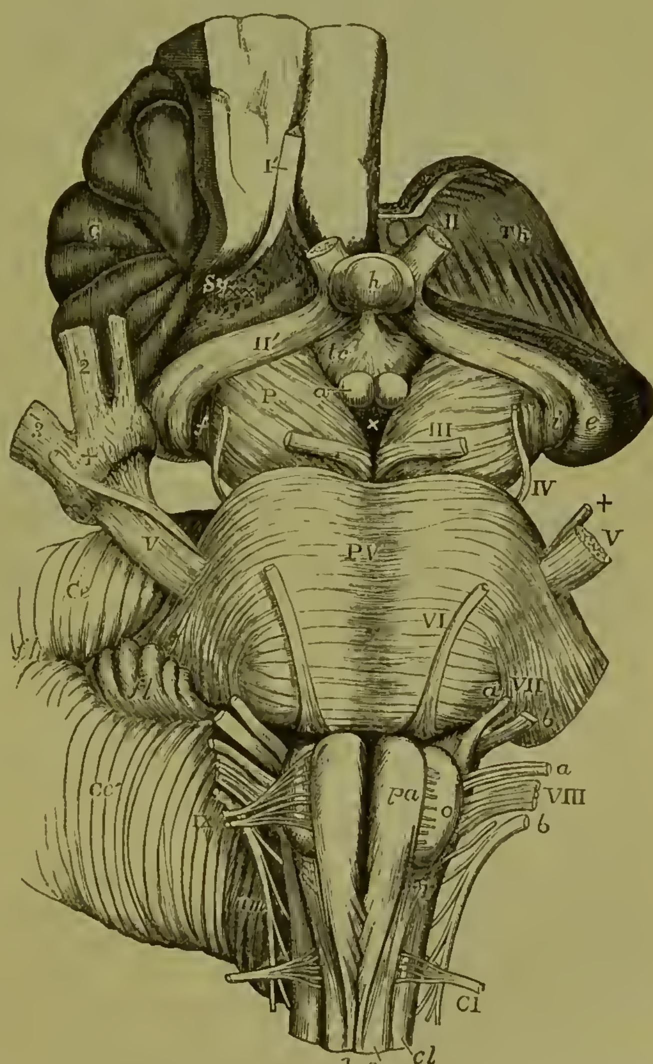


Fig. 397—View from below of the Connection of the Principal Nerves with the Brain.

The full description of this figure will be found at p. 538. The following references apply to the roots of the nerves: I', the right olfactory tract divided near its middle; II, the left optic nerve springing from the commissure which is concealed by the pituitary body; II', the right optic tract; the left tract is seen passing back into *i* and *e*, the internal and external corpora geniculata; III, the left oculomotor nerve; IV, the trochlear; V, V, the large roots of the trifacial nerves; + +, the lesser roots, the + of the right side is placed on the Gasserian ganglion; 1, the opthalmic; 2, the superior maxillary, and 3, the inferior maxillary nerves; VI, the left abducent nerve; VII, *a*, *b*, the facial and auditory nerves; *a*, VIII, *b*, the glosso-pharyngeal, pneumo-gastric, and spinal accessory nerves; IX, the right hypoglossal nerve; at *o*, on the left side, the rootlets are seen cut short; CI, the left suboccipital or first cervical nerve.

1. The first or *olfactory* nerve, as it is usually described, small in man in comparison with animals, lies on the under surface of the anterior lobe of the cerebrum to the outer side of the longitudinal median fissure, lodged in a sulcus between two straight convolutions. Unlike other nerves, it consists of a large proportion of grey matter mixed with white fibres, and indeed

agrees closely in structure with the cerebral substance. It swells into an oval enlargement, the *olfactory bulb*, in front, which also contains much grey matter, and from this part small soft nerves descend through the cribriform plate into the nose. When traced backwards, it is found to be spread out and attached behind to the under surface of the anterior lobe by means of *three roots*, named external, middle, and internal, which pass in different directions. The bulbous part is therefore rather to be regarded as an olfactory lobe of the cerebrum than as a part of a true nerve, while the white part prolonged backwards into the brain, together with its so-called roots, may be termed the olfactory tract.

The *external* or *long* root consists of a band of medullary fibres, which passes, in the form of a white streak, outwards and backwards along the anterior margin of the perforated space, towards the posterior border of the Sylvian fissure, where it may be followed into the substance of the cerebrum. Its further connections are doubtful, but it has been stated that its fibres have been traced to the following parts, viz., the convolutions of the island of Reil, the anterior commissure, and the superficial layer of the optic thalamus (Valentin).

The *middle* or *grey* root is of a pyramidal shape, and consists of grey matter on the surface, which is prolonged from the adjacent part of the anterior lobe and perforated space. Within it there are white fibres, which have been traced to the corpus striatum.

The *internal root* (short root, Scarpa), which cannot always be demonstrated, is composed of white fibres which may be traced from the inner and posterior part of the anterior lobe, where they are said by Foville to be connected with the longitudinal fibres of the gyrus fornicatus.

The question whether the olfactory bulbs ought to be considered as nerves or as cerebral lobes is, if tested by reference to the history of development, not so simple as might at first appear. It is in favour of their being regarded as lobes, that in the lower vertebrate animals the olfactory bulbs are generally recognised by comparative anatomists as additional encephalic lobes, and that in most mammals they are much larger proportionally than in man, and frequently contain a cavity or ventricle in their interior, and further that in their minute structure they nearly agree with the cerebrum; but as it is known that in the first development of the eye the peripheral part or retina, as well as the rest of the optic nerve, is originally formed by the extension of a hollow vesicle from the first fœtal encephalic compartment, so in the case of the olfactory nerve, although the peripheral or distributed part is of separate origin from the olfactory bulb, the latter part is comparable in its origin with the optic vesicle.

2. The *second* pair or *optic* nerves of the two sides meet each other at the optic commissure (chiasma), where they partially decussate. From this point they may be traced backwards round the crura cerebri, under the name of the optic tracts.

Each *optic tract* arises from the optic thalamus, the corpora quadrigemina, and the corpora geniculata. As it leaves the under part of the thalamus, it makes a sudden bend forwards and then runs obliquely across the under surface of the cerebral peduncle, in the form of a flattened band, which is attached by its anterior surface to the peduncle; after this, becoming more nearly cylindrical, it adheres to the tuber cinereum, from which and, as stated by Vicq-d'Azyr, from the lamina cinerea it is said to receive an accession of fibres, and thus reaches the optic commissure.

In the *commissure* the nerve-fibres of the two sides undergo a partial decussation. The outer fibres of each tract continue onwards to the eye of the

same side; the inner fibres cross over to the opposite side; and fibres have been described as running from one optic tract to the other along the posterior part of the commissure, while others pass between the two optic nerves in its anterior part (Mayo).

In front of the commissure, the nerve enters the foramen opticum, receiving a sheath from the dura mater and acquiring greater firmness.

Fig. 398.

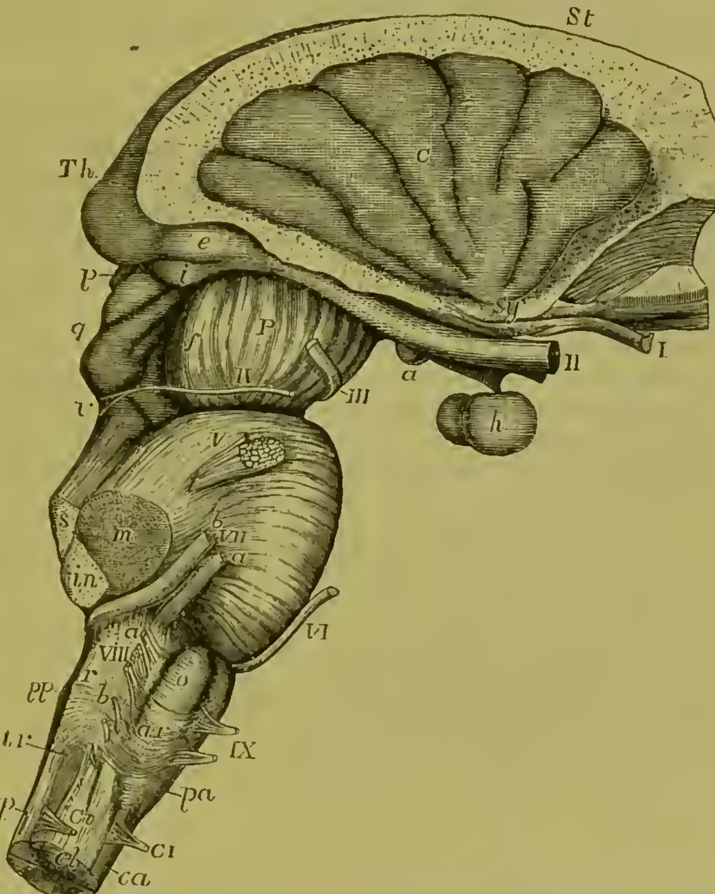


Fig. 398.—Lateral View of the Connection of the Principal Nerves with the Brain.

The full description of this figure will be found at p. 553. The following references apply to the roots of the nerves: I, the right olfactory tract cut near its middle; II, the optic nerves immediately in front of the commissure; the right optic tract is seen passing back to the thalamus (*Th*), corpora geniculata (*i, e,*), and corpora quadrigemina (*q*); III, the right oculo-motor nerve; IV, the trochlear nerve rising at *v*, from near the valve of Vieussens; V, the trifacial nerve; VI, the abducent ocular: *a*, VII, *b*, the facial and auditory nerves, and between them the pars intermedia; *a*, VIII, *b*, the roots of the glosso-pharyngeal, pneumo-gastric, and spinal accessory nerves; IX, the hypoglossal nerve; C I, the separate anterior and posterior roots of the suboccipital or first cervical nerve.

The fibres of origin of the optic tract from the thalamus are derived partly from the superficial stratum and partly from the interior of that body. According to Foville, this tract is also connected with the tænia semicircularis, and with the termination of the gyrus fornicatus; and he states further, that where the optic tract turns round the back of the thalamus and the cerebral peduncle it receives other delicate fibres, which descend from the grey matter of those parts.—(Op. cit. p. 514.)

3. The *third pair* of nerves (motores oculorum) have their apparent or superficial origin from the inner surface of the crura cerebri in the interpeduncular space, immediately in front of the pons. Each nerve consists of a number of funiculi which arise in an oblique line from the surface.

The deeper fibres of origin, when followed into the crus, are found to diverge in its substance, some being traced to the locus niger, others running downwards in the pons among its longitudinal fibres, and others turning upwards to be connected with the corpora quadrigemina and Vieussenian valve. According to Stilling, with whom Kölliker agrees, the major part of the fibres arise from a grey nucleus in the floor of the Sylvian aqueduct, close to the origin of some fibres of the fourth nerve.

4. The *fourth* pair, *pathetic* or *trochlear* nerves, the smallest of those which are derived from the brain, are seen at the outer side of the crura cerebri immediately before the pons. Each nerve may be traced backwards round the peduncle to a place below the corpora quadrigemina, where it arises from the upper part of the valve of Vieussens. Kölliker states that under the corpora quadrigemina the fibres of origin are divided into two bundles ; the anterior being traceable through the lateral wall of the aqueduct of Sylvius to its floor, where it arises from a grey nucleus close to the middle line ; the posterior bundle being derived from a grey nucleus in the floor of the fourth ventricle, close to the origin of the fifth nerve. The roots of the nerves of opposite sides are connected together across the middle line in the form of a white band or commissure in the substance of the velum.

5. The *fifth* pair of nerves, par trigeminum, *trifacial nerves*, take their superficial origin from the side of the pons Varolii, where the transverse fibres of the latter are prolonged into the middle crus cerebelli, considerably nearer to the upper than to the lower border of the pons.

The fifth nerve consists of a larger or sensory, and a smaller or motor root. The smaller root is at first concealed by the larger, and is placed a little higher up, there being often two or three cross fibres of the pons between them. On separating the two roots, the lesser one is seen to consist of a very few funiculi. In the larger root the funiculi are numerous, amounting sometimes to nearly a hundred.

Deep origin.—The *greater* root runs behind the transverse fibres of the pons towards the lateral part of the medulla oblongata at the back of the olivary body. Several anatomists trace it into the floor of the fourth ventricle, between the fasciculi teretes and the restiform bodies. By some it is considered to be continuous with the fasciculi teretes and lateral columns of the cord, whilst others connect it with the grey mass which is regarded by Stilling as the nucleus of the glosso-pharyngeal nerve.

The *motor* root was supposed by Bell to descend to the pyramidal body, and Retzius believes that he has confirmed that opinion by dissection : but it would appear that the deep connection of this root is not yet known with certainty. According to Stilling the fibres pass through the pons to the floor of the fourth ventricle, and have their origin in its grey matter.

According to Foville, some of the fibres of the sensory root of the fifth nerve are connected with transverse fibres in the pons, whilst others spread out on the surface of the middle peduncle of the cerebellum, and enter that part of the encephalon beneath the folia.—(Op. cit. p. 506.)

6. The *sixth* nerve (abducens), *motor oculi externus*, takes its apparent origin from between the pyramidal body and the pons Varolii by means of a larger and a smaller bundle. It is connected with the pyramid, and to a small extent with the pons also. Phillipeaux and Vulpian, with whom

Kölliker concurs, state that the fibres may be traced more deeply to the floor of the fourth ventricle.

7. The *seventh* pair of nerves appear on each side at the posterior margin of the pons, between the middle and inferior peduncles of the cerebellum, and nearly in a line with the place of attachment of the fifth nerve.

Deep origins.—The *portio dura* or *facial* nerve, placed a little nearer to the middle line than the portio mollis, may be traced to the medulla oblongata between the restiform and olivary fasciculi, with both of which it is said to be connected. Some of its fibres are derived from the pons. Phillipeaux and Vulpian affirm that the fibres arise from the outer wall of the fourth ventricle, and that many of them decussate in its floor.

Connected with the portio dura, and intermediate between it and the portio mollis, is a smaller white funiculus, first described by Wrisberg (portio inter duram et mollem). The roots of this accessory or intermediate portion are connected deeply with the lateral column of the cord.

The *portio mollis*, or auditory nerve, rises from the floor of the fourth ventricle, at the back of the medulla oblongata, in which situation, as already described, transverse white striæ are seen, which form the commencement of the nerve. These roots are connected with the grey matter, and some appear to come out of the median fissure. The nerve then turns round the restiform body, and becomes applied to the lower border of the pons, receiving accessions from the former of those parts, and according to some authors from the latter also.

Foville says that the roots of the portio mollis are also connected by a thin layer on the under surface of the middle peduncle with the cortical substance of the cerebellum; also, with the small lobule named the flocculus; and with the grey matter at the borders of the calamus scriptorius.

8. The *eighth* nerve consists of three distinct portions.

The uppermost portion is the *glosso-pharyngeal* nerve ; next to this, and lower down, is the *par vagum* or *pneumo-gastric* nerve consisting of a larger number of cords. The roots of both these nerves are attached superficially to the fore part of the restiform body. Still lower, is the *spinal accessory* nerve, which, ascending from the side of the spinal cord, enters the skull by the foramen magnum, and is associated with the pneumo-gastric nerve as it passes out through the foramen lacerum.

The accessory nerve arises within the spinal canal from the lateral column of the cord, behind its middle, by a series of slender roots, which commence as low down as the fifth or sixth cervical nerve. The nerve passes upwards between the posterior roots of the cervical nerves and the ligamentum denticulatum,—the several funiculi of origin successively joining it as it ascends. On entering the skull, it receives funiculi from the side of the medulla oblongata.

These three portions of the eighth pair are connected deeply with grey nuclei within the cord and medulla oblongata, as already described (see p. 521).

9. The *ninth* nerve (hypoglossal) arises, in a line continuous with that of the anterior roots of the spinal nerves, by scattered funiculi from the furrow between the olivary body and the anterior pyramid.

The roots of the ninth nerve are traced by Stilling to one of the grey nuclei already described in the medulla oblongata, and they are said by Kölliker to undergo partial decussation in the floor of the fourth ventricle.

DISTRIBUTION OF THE CRANIAL NERVES.

Mode of exit from the cranium.—Each of the cranial nerves issues at first from the cranial cavity through a foramen or tubular prolongation of the dura mater : some of those nerves or their main divisions are contained

in distinct foramina of the cranium, others are grouped together in one foramen. The numerous small olfactory nerves descend into the nose through the cribriform plate of the ethmoid bone ; the optic nerve pierces the root of the lesser wing of the sphenoid bone, the third, fourth, and sixth nerves, with the ophthalmic division of the fifth nerve, pass through the

Fig. 399.

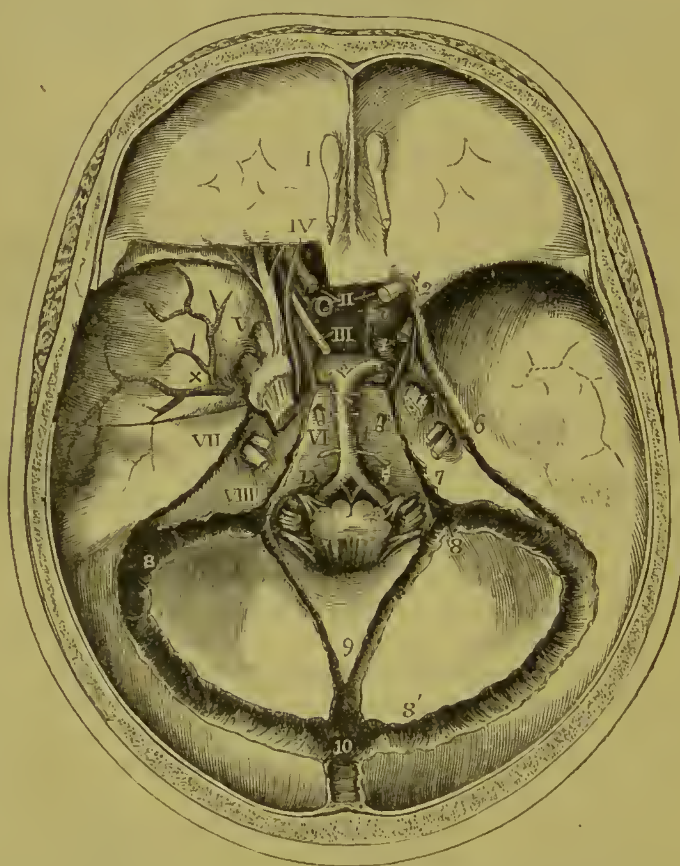


Fig. 399.—Internal View of the Base of the Skull, showing the places of exit of the Cranial Nerves.

The dura mater is left in great part within the base of the skull ; the tentorium is removed and the venous sinuses are opened. On the left side a small portion of the roof of the orbit has been removed to show the relation of certain nerves at the cavernous sinus and in the sphenoidal fissure. The roots of the several cranial nerves have been divided at a short distance inside the foramina of the dura mater through which they respectively pass. I, the bulb of the olfactory nerve lying over the cribriform plate of the ethmoid bone ; II, the optic nerves, that of the left side cut short ; III, placed on the pituitary body, indicates the common oculo-motor nerve ; IV, the trochlear nerve ; V, is placed on the left side opposite to the middle of the three divisions of the trigeminus, which, together with the ganglion and greater root, have been exposed by opening up the dura mater ; on the right side the greater root is seen ; VI, placed below the foramen of exit of the abducent ocular ; VII, placed on the upper part of the petrous bone opposite the entrance of the facial and auditory nerves into the meatus auditorius internus ; VIII, placed on the petrous bone outside the jugular foramen opposite the place of exit of the three divisions of the eighth pair of nerves ; IX, placed upon the basilar part of the occipital bone in front of the hypoglossal nerve as it passes through the anterior condyloid foramen. On the left side at the cavernous sinus, the third, fourth, and ophthalmic division of the fifth nerves are seen keeping towards the outer side, while the sixth nerve is deeper and close to the internal carotid artery. The explanation of the remaining references in this figure will be found at p. 461.

sphenoidal fissure ; the superior maxillary and inferior maxillary divisions of the fifth pass respectively through the foramen rotundum and foramen ovale of the great wing ; the facial and auditory nerves pierce the petrous bone ; the three parts of the eighth pair descend in separate canals of the dura mater through the anterior part of the jugular foramen between the petrous and occipital bones, and the hypoglossal nerve passes through the anterior condyloid foramen of the occipital bone.

General distribution.—The greater number of the cranial nerves are entirely confined in their distribution within the limits of the head ; as in the case of the first six pairs and the auditory nerve. Of these the olfactory, optic, and auditory are restricted to their respective organs of sense ; while the third, fourth, and sixth are exclusively motor nerves in connection with the external and internal muscles of the eyeball and that of the upper eyelid. In the remaining nerve, the fifth or trifacial, all the fibres derived from the greater root, and connected with the Gasserian ganglion, are entirely sensory in their function, and constitute the whole of the first and second and the greater part of the third division of the nerve : but the last of these divisions has associated with it the fibres of the lesser root, so as to become in some degree a compound nerve. As a nerve of sensation the trifacial occupies in its distribution the greater part of the head superficially and deeply, excepting the interior of the cranium and that part of the scalp which is situated in the region behind a perpendicular line passing through the external auditory meatus. The muscular distribution of the inferior division of the fifth nerve is chiefly to the muscles of mastication.

Of the remaining nerves, the facial and hypoglossal, both exclusively motor in function, are almost entirely cephalic in their distribution ; the facial nerve giving fibres to all the superficial and a few of the deeper muscles of the head and face ; and the ninth or hypoglossal supplying the muscles of the tongue. Of the facial, however, a small branch joins one of the cervical nerves in the platysma myoides ; and of the ninth, the descending branch supplies in part the muscles of the neck which depress the hyoid bone and larynx.

Of the three parts of the eighth pair, ranked as cranial nerves in consequence of their passing through one of the foramina of the cranium, two have only a very limited distribution in the head, and furnish nerves in much greater proportion to organs situated in the neck and thorax. One of these, the pneumo-gastric, after giving a small branch to the ear-passages, and supplying nerves to the larynx and pharynx, the trachea, gullet, the lungs and heart, extends into the abdominal cavity as the principal nerve of the stomach. The other, the spinal accessory, which is partially united with the glosso-pharyngeal and pneumo-gastric near their origin and thus furnishes some of their motor fibres, is entirely a motor nerve, and is distributed in the sterno-mastoid and trapezius muscles. The glosso-pharyngeal nerve is more strictly confined to the head, supplying branches to the tongue, pharynx, and part of the ear-passages.

On the following two pages, Fig. 401 is introduced in illustration of the general view of the distribution above given. In this figure the cranium and orbit have been opened up to the depth of the several foramina through which the nerves pass. The greater part of the lower jaw has also been removed on the left side, and the tongue, pharynx, and larynx are partially in view. The occipital bone has been divided by an incision passing down from the occipital tuberosity and through the condyle to the left of the foramen magnum. The cervical vertebræ have been divided to the left of

the middle, and the sheath of the spinal cord opened so as to expose the roots of the cervical nerves.

Fig. 400, A.

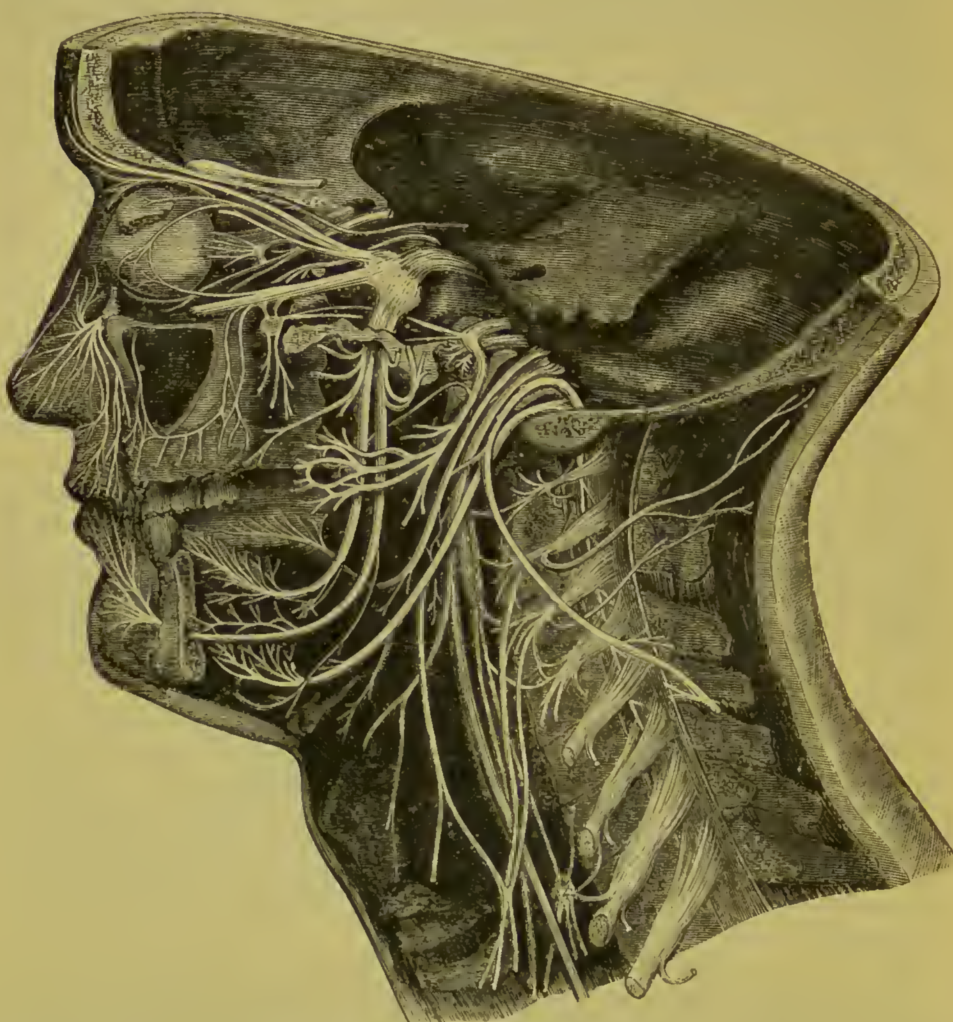
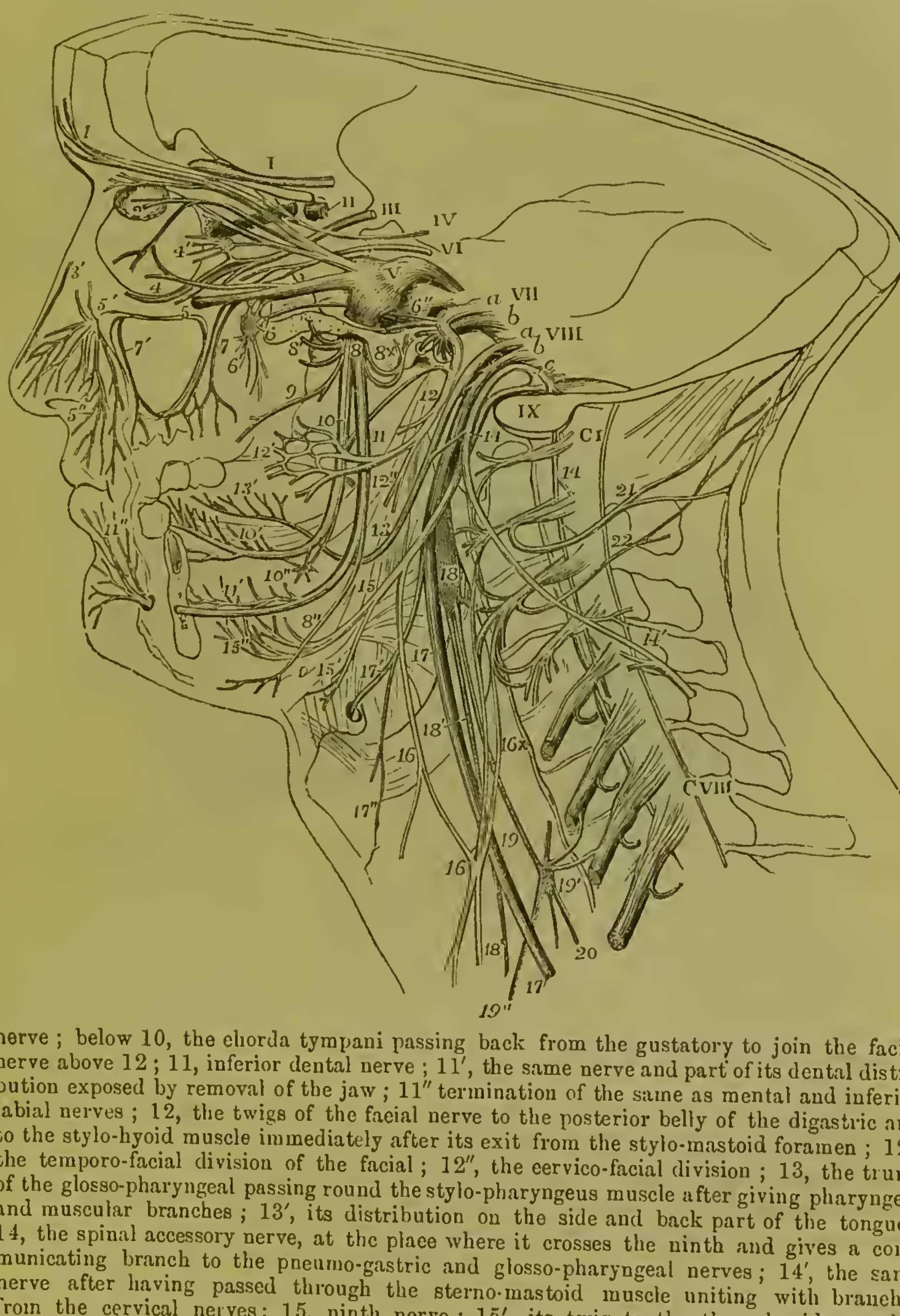


Fig. 400.—A. Semidiagrammatic View of a Deep Dissection of the Cranial Nerves on the left side of the Head (from various authors and from nature). B. Explanatory Outline of the same. ½

The roman numerals from I to IX indicate the roots of the several cranial nerves as they lie in or near their foramina of exit. V, is upon the great root of the fifth with the ganglion in front; *a* and *b*, in connection with VII, indicate respectively the facial and auditory nerves; *a*, *b*, and *c*, in connection with VIII, point respectively to the glosso-pharyngeal, pneumo-gastric, and spinal accessory nerves; C I, the sub-occipital or first cervical nerve; C VIII, the eighth. The branches or distributed parts of the nerves are marked as follows, viz.:—1, frontal branch of the fifth; 2, lachrymal passing into the gland; 3, nasal passing towards the internal orbitary foramen and giving the long twig to the ciliary ganglion (4′); 3′, external branch of the internal nasal nerve; 4, lower branch of the third or oculo-motor nerve; 5, the superior maxillary division of the fifth passing into the infra-orbital canal; 5′, its issue at the infraorbital foramen and distribution as inferior palpebral, lateral nasal, and superior labial nerves (5″); 6, ganglion of Meckel and Vidian nerve passing back from it; 6′, palatine and other nerves descending from it; 6″, superior petrosal nerve; 7, posterior superior dental nerves; 7′, placed in the antrum maxillare, which has been opened, points to the anterior superior dental nerves; 8, inferior maxillary division of the fifth immediately below the foramen ovale; 8′, some of the muscular branches coming from it; 8 ×, the anterior auricular branch cut short, and above it the small petrosal nerve to join the facial nerve; 9, buccal and internal ptery-

goid; 10, gustatory nerve; 10′, its distribution to the side and front of the tongue and to the sublingual glands; 10″, the submaxillary ganglion connected with the gustatory

Fig. 400, B.



nerve; below 10, the chorda tympani passing back from the gustatory to join the facial nerve above 12; 11, inferior dental nerve; 11′, the same nerve and part of its dental distribution exposed by removal of the jaw; 11″ termination of the same as mental and inferior labial nerves; 12, the twigs of the facial nerve to the posterior belly of the digastric and to the stylo-hyoid muscle immediately after its exit from the stylo-mastoid foramen; 12′, the temporo-facial division of the facial; 12″, the cervico-facial division; 13, the trunk of the glosso-pharyngeal passing round the stylo-pharyngeus muscle after giving pharyngeal and muscular branches; 13′, its distribution on the side and back part of the tongue; 14, the spinal accessory nerve, at the place where it crosses the ninth and gives a communicating branch to the pneumo-gastric and glosso-pharyngeal nerves; 14′, the same nerve after having passed through the sterno-mastoid muscle uniting with branches from the cervical nerves; 15, ninth nerve; 15′, its twig to the thyro-hyoid muscle; 15″, its distribution in the muscles of the tongue; 16, descendens noni nerve giving a direct branch to the upper belly of the omo-hyoid muscle, and receiving the communicating branches 16 × from the cervical nerve; 17, pneumo-gastric nerve; 17′, its superior laryngeal branch; 17″, external laryngeal twig; 18, superior cervical ganglion of the sympathetic nerve, uniting with the upper cervical nerves, and giving at 18′ the superficial cardiac nerve; 19, the trunk of the sympathetic; 19′, the middle cervical ganglion, uniting with some of the cervical nerves, and giving 19″, the large middle cardiac nerve; 20, continuation of the sympathetic nerve down the neck; 21, great occipital nerve; 22, third occipital.

OLFACTORY NERVE.

The olfactory or first cranial nerve, the special nerve of the sense of smell, is distributed exclusively to the nasal fossæ.

From the under surface of the olfactory bulb about twenty branches proceed through the holes in the cribriform plate of the ethmoid bone, each invested by tubular prolongations of the membranes of the brain. These tubes of membrane vary in the extent to which they are continued on the branches: the offsets of the dura mater sheathe the filaments, and join the periosteum lining the nose; those of the pia mater become blended with the neurilemma of the nerves; and those of the arachnoid re-ascend to the serous lining of the skull.

Fig. 401.

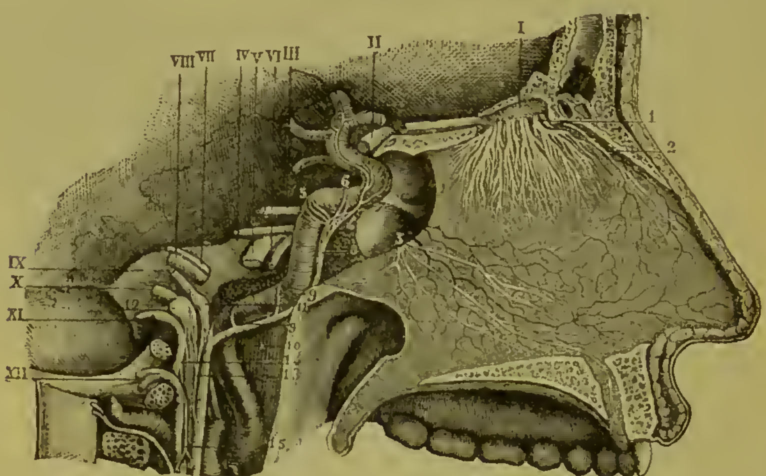


Fig. 401.—Distribution of the Olfactory Nerves on the Septum of the Nose (from Sappey after Hirschfeld and Leveillé). ⅔

The septum is exposed and the anterior palatine canal opened on the right side. I, placed above, points to the olfactory bulb, and the remaining roman numbers to the roots of the several cranial nerves; 1, the small olfactory nerves as they pass through the cribriform plate; 2, internal or septal twig of the nasal branch of the ophthalmic nerve; 3, naso-palatine nerves. (See Fig. 409 for a view of the distribution of the olfactory nerves on the outer wall of the nasal fossa.)

The branches are arranged in three sets. Those of the inner set, lodged for some distance in grooves on the surface of the bone, ramify in the pituitary membrane of the septum; the outer set extend to the upper two spongy bones, and the plane surface of the ethmoid bone in front of these; and the middle set, which are very short, are confined to the roof of the nose. The distribution of the olfactory nerve is confined to the upper part of the nasal fossa; none of the branches reach the lower spongy bone.—(See Anatomy of the Nose.)

OPTIC NERVE.

The optic or second cranial nerve, the nerve of vision, extending from the optic commissure, becomes more cylindrical and firm as it diverges from its fellow and enters the orbit by the optic foramen. Within the orbit it forms a cylindrical trunk, thick and strong, with a uniform surface. On dis-

section it is seen to consist of a number of separate bundles of nerve fibres, imbedded in tough fibrous tissue prolonged from the dura mater, and perforated in the centre by the small arteria centralis retinæ, which passes into it soon after it enters the orbit. It is surrounded by the recti muscles, and, entering the eyeball posteriorly a little to the inside of its middle, it pierces the sclerotic and choroid coats, and expands in the retina.—(See the Anatomy of the Eye.)

It may be mentioned that in many fishes the optic nerves do not unite in a commissure, but merely cross each to the side opposite to that of their origin; and that in a number of the same animals, as was first pointed out by Malphighi, the nerve consists of a lamina thrown into complicated longitudinal plications, and surrounded by a sheath.

THIRD PAIR OF NERVES.

This nerve, the common motor nerve of the eyeball (motorius oculi), gives branches to five of the seven muscles of the orbit,—viz., to the

Fig. 402.

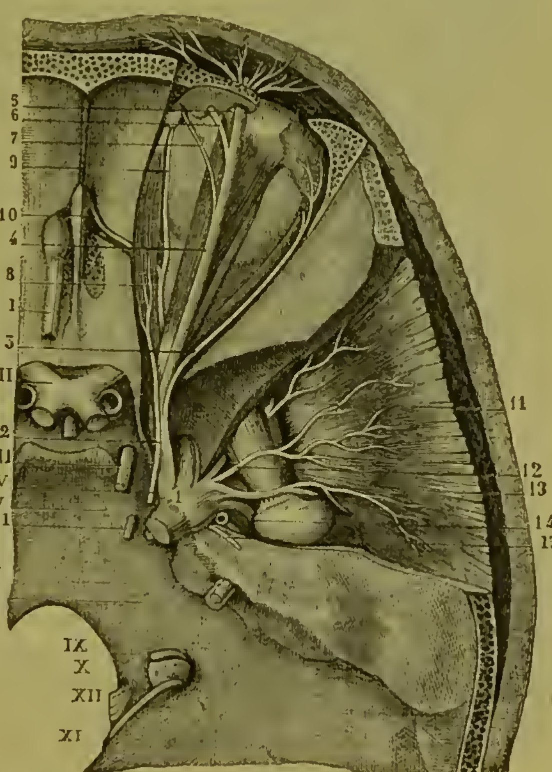


Fig. 402.—View from above of the Uppermost Nerves of the Orbit, the Gasserian Ganglion, &c. (from Sappey after Hirschfeld and Leveillé). ⅔

I, the olfactory tract passing forwards into the bulb; II, the commissure of the optic nerves; III, the oculo-motor; IV, the trochlear nerve; V, the greater root of the fifth nerve, a small portion of the lesser root is seen below it; VI, the sixth nerve; VII, facial; VIII, auditory; IX, glosso-pharyngeal; X, pneumo-gastric; XI, spinal accessory; XII, hypoglossal; 1, the Gasserian ganglion; 2, ophthalmic nerve; 3, lachrymal branch; 4, frontal; 5, external frontal or supraorbital; 6, internal frontal; 7, supratrochlear branch; 8, nasal nerve; 9, infratrochlear branch; 10, internal nasal passing through the internal orbital foramen; 11, anterior deep temporal proceeding from the buccal nerve; 12, middle deep temporal; 13, posterior deep temporal arising from the masseteric; 14, origin of the temporo-auricular; 15, great superficial petrosal nerve.

superior, internal and inferior straight muscles, to the levator palpebræ, and to the inferior oblique muscle.

Cylindrical and firm, like the other motor nerves, the third nerve, quitting the investment of the arachnoid membrane, pierces the inner layer of the dura mater close to the posterior clinoid process, and proceeds towards the sphenoidal fissure, lying in the external fibrous boundary of the cavernous sinus.

After receiving one or two delicate filaments from the cavernous plexus of the sympathetic, the third nerve divides near the orbit into two parts, which are continued into that cavity between the heads of the external rectus muscle, and separated one from the other by the nasal branch of the ophthalmic nerve.

The *upper*, the smaller part, is directed inwards over the optic nerve to the superior rectus muscle of the eye and the elevator of the eyelid, to both which muscles it furnishes branches.

The *lower* and larger portion of the nerve separates into three branches ; of these one reaches the inner rectus ; another the lower rectus ; and the third, the longest of the three, runs onwards between the lower and the outer rectus, and terminates below the ball of the eye in the inferior oblique muscle. The last-mentioned branch is connected with the lower part of the lenticular ganglion by a short thick cord, and gives two filaments to the lower rectus muscle.

The several branches of the third nerve enter the muscles to which they are distributed on the surface which in each looks towards the eyeball.

Position of certain nerves *at the cavernous sinus, and as they enter the orbit.*—There are several nerves, besides the third, placed close together at the cavernous sinus, and entering the orbit through the sphenoidal fissure. To avoid repetition hereafter, the relative positions of these nerves may now be described. The nerves thus associated are the third, the fourth, the ophthalmic division of the fifth, and the sixth.

At the cavernous sinus.—In the dura mater which bounds the cavernous sinus on the outer side, the third and fourth nerves and the ophthalmic division of the fifth are placed, as regards one another, in their numerical order both from above downwards and from within outwards. The sixth nerve is placed separately from the others close to the carotid artery, on the floor of the sinus and internal to the fifth nerve. Near the sphenoidal fissure, through which they enter the orbit, the relative position of the nerves is changed, the sixth nerve being here close to the rest, and their number is augmented by the division of the third and the ophthalmic nerves—the former into two, the latter into three parts.

In the sphenoidal fissure.—The fourth, and the frontal and lachrymal branches of the fifth, which are here higher than the rest, lie on the same level, the fourth being the nearest to the inner side, and enter the orbit above the muscles. The remaining nerves pass between the heads of the outer rectus muscle, in the following relative position to each other : the upper division of the third highest, the nasal branch of the fifth next, the lower division of the third beneath these, and the sixth lowest of all.

FOURTH PAIR OF NERVES.

The fourth (nervus trochlearis, n. patheticus) is the smallest of the cranial nerves, and is distributed entirely to the upper oblique muscle of the orbit.

From the remoteness of its place of origin, the part of this nerve within the skull is longer than that of any other cranial nerve. It enters an aperture in the free border of the tentorium, outside that for the third nerve, and near the posterior clinoid process. Continuing onwards through the outer wall of the cavernous sinus, the fourth nerve enters the orbit by the sphenoidal fissure, and above the muscles. Its position with reference to other nerves in this part of its course has been already described.

In the orbit, the fourth nerve inclines inwards above the muscles, and enters finally the upper oblique muscle at its orbital surface.

While in its fibrous canal in the outer wall of the sinus, the fourth nerve is joined by filaments of the sympathetic, and not unfrequently is blended with the ophthalmic

Fig. 403.

Fig. 403.—View from above of the Motor Nerves of the Eyeball and its Muscles (after Hirschfeld and Leveillé, altered).

The ophthalmic division of the fifth pair has been cut short; the attachment of the muscles round the optic nerve has been opened up, and the three upper muscles turned towards the inner side, their anterior parts being removed; a part of the optic nerve is cut away to show the inferior rectus; and a part of the sclerotic coat and cornea is dissected off showing the iris, zona ciliaris, and choroid coat, with the ciliary nerves.

a, the upper part of the internal carotid artery emerging from the cavernous sinus; *b*, the superior oblique muscle; *b'*, its anterior part passing through the pulley; *c*, the levator palpebræ superioris; *d*, the superior rectus; *e*, the internal rectus; *f*, the external rectus; *f'*, its upper tendon turned down; *g*, the inferior rectus; *h*, insertion of the inferior oblique muscle.

II, the commissure of the optic nerve; II', part of the optic nerve entering the eyeball; III, the common oculo-motor; IV, the fourth or trochlear nerve; V, the greater root of the trigeminus; V', the smaller or motor root; VI, the abducent nerve; 1, the upper division of the third nerve separating from the lower and giving twigs to the levator palpebræ and superior rectus; 2, the branches of the lower division supplying the internal and inferior recti muscles; 3, the long branch of the same nerve proceeding forward to the inferior oblique muscle, and close to the number 3, the short thick branch to the ciliary ganglion: this ganglion is also shown, receiving from behind the slender twig from the nasal nerve, which has been cut short, and giving forwards some of its ciliary nerves, which pierce the sclerotic coat; 3', marks the termination of some of these nerves in the ciliary muscle and iris after having passed between the sclerotic and choroid coats; 4, the distribution of the trochlear nerve to the upper surface of the superior oblique muscle; 6, the abducent nerve passing into the external rectus.

division of the fifth. Bidder states that three or more small filaments of this nerve extend in the tentorium as far as the lateral sinus; and has figured one as joining the sympathetic on the carotid artery. (Neurologische Beobachtungen, Von F. H. Bidder. Dorpat, 1836.)

FIFTH PAIR OF NERVES.

The fifth, or trifacial nerve (nerv. trigeminus), the largest cranial nerve, is analogous to the spinal nerves, in respect that it consists of a motor and a sensory part, and that the sensory fibres pass through a ganglion while the motor do not. Its sensory division, which is much the larger, imparts common sensibility to the face and the fore part of the head, as well as to the eye, the nose, the ear, and the mouth; and endows the fore part of the tongue with the powers of both touch and taste. The motor root supplies chiefly the muscles of mastication.

The roots of the fifth nerve, after emerging from the surface of the encephalon, are directed forwards, side by side, to the middle fossa of the skull, through a recess in the dura mater on the summit of the petrous part of the temporal bone. Here the larger root alters in appearance : its

Fig. 404.

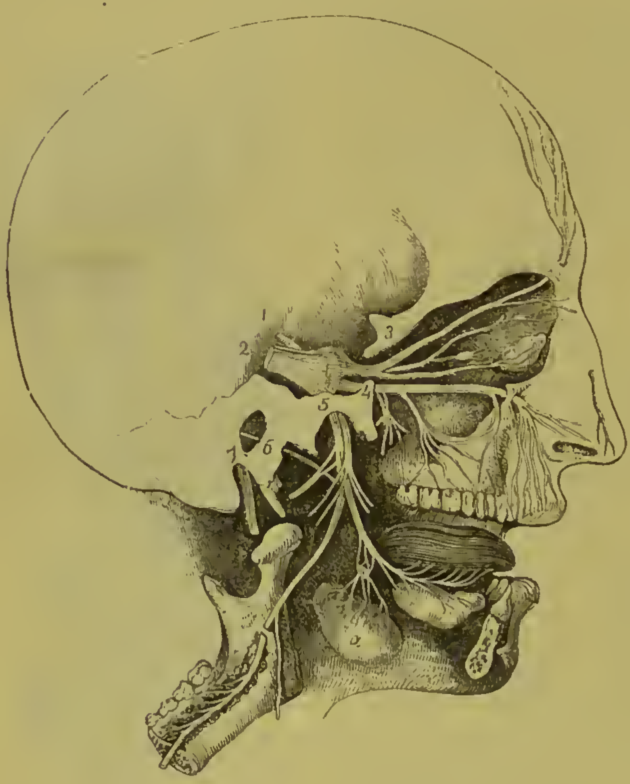


Fig. 404. — General Plan of the Branches of the Fifth Pair (after a sketch by Charles Bell) $\frac{1}{3}$

1, lesser root of the fifth pair ; 2, greater root passing forwards into the Gasserian ganglion ; 3, placed on the bone above the ophthalmic nerve, which is seen dividing into the supraorbital, lachrymal, and nasal branches, the latter connected with the ophthalmic ganglion ; 4, placed on the bone close to the foramen rotundum, marks the superior maxillary division, which is connected below with the spheno-palatine ganglion, and passes forwards to the infraorbital foramen ; 5, placed on the bone over the foramen ovale, marks the submaxillary nerve, giving off the anterior auricular and muscular branches, and continued by the inferior dental to the lower jaw, and by the gustatory to the tongue ; *a*, the submaxillary gland, the submaxillary ganglion placed above it in connection with the gustatory nerve ; 6, the chorda tympani ; 7, the facial nerve issuing from the stylo-mastoid foramen.

fibres diverge a little, become reticulated, and enter the Gasserian ganglion. The smaller root passes inside and beneath the ganglion, without its nerve-fibres being incorporated in any way with it, and joins outside the skull the lowest of the three trunks which issue from the ganglion.

The *ganglion of the fifth nerve*, or *Gasserian ganglion* (ganglion semilunare), occupies a depression on the upper part of the petrous portion of the temporal bone, near the point, and is somewhat crescentic in form, the convexity being turned forwards. On its inner side the ganglion is joined by filaments from the carotid plexus of the sympathetic nerve, and, according to some anatomists, it furnishes from its back part filaments to the dura mater.

From the fore part, or convex border of the Gasserian ganglion, proceed the three large divisions of the nerve. The highest (first or ophthalmic trunk) enters the orbit ; the second, the upper maxillary nerve, is continued forwards to the face, below the orbit ; and the third, the lower maxillary nerve, is distributed chiefly to the external ear, the tongue, the lower teeth, and the muscles of mastication. The first two trunks proceed exclusively from the

ganglion and are entirely sensory, while the third or inferior maxillary trunk, receiving a considerable part from the ganglion, has associated with it also the whole of the fibres of the motor root, and thus distributes both motor and sensory branches.

OPHTHALMIC NERVE.

The ophthalmic nerve, or first division of the fifth nerve, the smallest of the three offsets from the Gasserian ganglion, is somewhat flattened, about an inch in length, and is directed forwards and upwards to the sphenoidal fissure, where it ends in branches which pass through the orbit to the surface of the head and to the nasal fossæ. In the skull it is contained in the process of the dura mater bounding externally the cavernous sinus, and is joined by filaments from the cavernous plexus of the sympathetic : according to Arnold, it gives recurrent branches to the tentorium cerebelli. It also frequently communicates by a considerable branch with the fourth nerve.

Near the orbit the ophthalmic nerve furnishes from its inner side the nasal branch, and then divides into the frontal and lachrymal branches. These branches are transmitted separately through the sphenoidal fissure, and are continued through the orbit (after supplying some filaments to the eye and the lachrymal gland) to their final distribution in the nose, the eyelids, and the muscles and integument of the forehead.

LACHRYMAL BRANCH.

The lachrymal branch is external to the frontal at its origin, and is contained in a separate tube of dura mater. In the orbit it passes along the outer part, above the muscles, to the outer and upper angle of the cavity. Near the lachrymal gland, the nerve has a connecting filament with the orbital branch of the superior maxillary nerve ; and when in close apposition with the gland, it gives many filaments to that body and to the conjunctiva. Finally, the lachrymal nerve penetrates the palpebral ligament externally, and ends in the upper eyelid, the terminal ramifications being joined by twigs from the facial nerve.

In consequence of the junction which occurs between the ophthalmic trunk of the fifth and the fourth nerve, the lachrymal branch sometimes appears to be derived from both these nerves. Swan considers this the usual condition of the lachrymal nerve. ("A Demonstration of the Nerves of the Human Body," page 36. London, 1834.)

FRONTAL BRANCH.

The frontal branch, the largest division of the ophthalmic, lies, like the preceding nerve, above the muscles in the orbit, being situated between the elevator of the upper eyelid and the periosteum. About midway forwards in the orbit, the nerve divides into two branches, supra-trochlear and supra-orbital.

a. The *supra-trochlear branch* (internal frontal) is prolonged to the inner angle of the orbit, close to the point at which the pulley of the upper oblique muscle is fixed to the orbit. Here it gives downwards a filament to connect it with the infra-trochlear branch of the nasal nerve, and issues from the cavity between the orbicular muscle of the lids and the bone. In this position filaments are distributed to the upper eyelid. The nerve next pierces the

orbicularis palpebrarum and occipito-frontalis muscles, furnishing twigs to these muscles and the corrugator supercilii, and, after ascending on the forehead, ramifies in the integument.

b. The *supra-orbital branch* (external frontal) passes through the supra-orbital notch to the forehead, and ends in muscular, cutaneous, and pericranial branches; while in the notch it distributes *palpebral* filaments to the upper eyelid.

The *muscular branches* referred to are comparatively small, and supply the corrugator of the eyebrow, the occipito-frontalis, and the orbicular muscle of the eyelids, joining the facial nerve in the last muscle. The *cutaneous branches*, among which two (outer and inner) may be noticed as the principal, are placed at first beneath the occipito-frontalis. The outer one, the larger, perforates the tendinous expansion of the muscle, and ramifies in the scalp as far back as the lambdoidal suture. The inner branch reaches the surface sooner than the preceding nerve, and ends in the integument over the parietal bone. The *pericranial branches* arise from the cutaneous nerve beneath the muscle, and end in the pericranium covering the frontal and parietal bones.

Fig. 405.

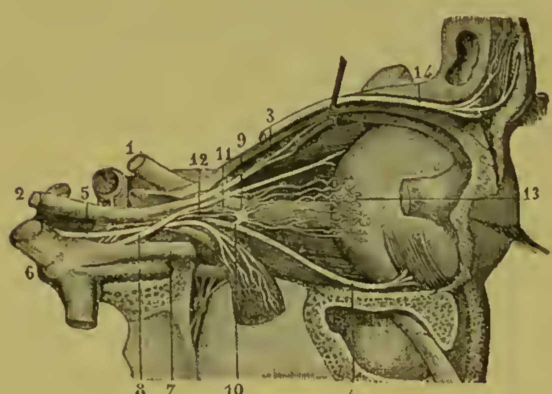


Fig. 405.—Nerves of the Orbit from the Outer Side (from Sappey after Hirschfeld and Leveillé). $\frac{3}{4}$

The external rectus muscle has been divided and turned down: 1, the optic nerve; 2, the trunk of the third nerve; 3, its upper division passing into the levator palpebræ and superior rectus; 4, its long lower branch to the inferior oblique muscle; 5, the sixth or abducent nerve joined by twigs from the sympathetic; 6, the Gasserian ganglion; 7, ophthalmic nerve; 8, its nasal branch; 9, the ophthalmic ganglion; 10, its short or motor root; 11, long sensory root from the nasal nerve; 12, sympathetic twig from the carotid plexus; 13, ciliary nerves passing into the eyeball; 14, frontal branch of the ophthalmic nerve.

NASAL BRANCH.

The nasal branch (oculo-nasalis), separating from its parent trunk in the wall of the cavernous sinus, enters the orbit between the heads of the outer rectus. It then inclines inwards over the optic nerve, beneath the elevator of the upper eyelid and the superior rectus muscle, to the inner wall of the orbit, through which it passes by the anterior internal orbital foramen. In this oblique course across the orbit it furnishes a single filament to the ophthalmic ganglion, two or three (long ciliary) directly to the eyeball; and, at the inner side of the cavity, a considerable branch (infra-trochlear), which issues from the orbit at the fore part.

On leaving the orbit the nasal nerve is directed transversely inwards to the upper surface of the cribriform plate of the ethmoid bone, and passing forwards in a groove at its outer edge, within the cranium, descends by a special aperture close to the crista galli at the fore part of the plate to the roof of the nasal fossa, where it divides into two branches, one of which (external or superficial nasal) reaches the integument of the side of the nose, and the other (ramus septi) ramifies in the pituitary membrane.

a. The *branch to the ophthalmic ganglion* (radix longa ganglii ciliaris), very slender, and about half an inch long, arises generally between the heads of the external rectus: it lies on the outer side of the optic nerve, and enters the upper and back part of the ophthalmic ganglion, constituting its *long root.*

This small branch is sometimes joined by a filament from the cavernous plexus of the sympathetic, or from the upper branch of the third nerve.

b. The *long ciliary nerves,* two or three in number, are situated on the inner side of the optic nerve; they join one or more of the nerves from the ophthalmic ganglion (short ciliary), and after perforating the sclerotic coat of the eye, are continued between it and the choroid to the ciliary muscle, the cornea, and the iris.

c. The *infra-trochlear branch* runs forwards along the inner side of the orbit below the superior oblique muscle, and receives near the pulley of that muscle a filament of connection from the supra-trochlear nerve. The branch is then continued below the pulley to the inner angle of the eye, and ends in filaments which supply the orbicular muscle of the lids, the caruncula, and the lachrymal sac, as well as the integument of the eyelids and side of the nose.

In the cavity of the nose the nasal nerve ends by dividing into the following branches:—

d. The *branch to the nasal septum* extends to the lower part of the partition between the nasal fossæ, supplying the pituitary membrane near the fore part of the septum.

e. The *superficial branch* (externus seu lateralis), descends in a groove on the inner surface of the nasal bone: and after leaving the nasal cavity between that bone and the lateral cartilage of the nose, it is directed downwards to the tip of the nose, beneath the compressor naris muscle. While within the nasal fossa, this branch gives two or three filaments to the fore part of its outer wall, which extend as far as the lower spongy bone. The cutaneous part is joined by a filament of the facial nerve.

Summary.—The first division of the fifth nerve is altogether sensory in function. It furnishes branches to the ball of the eye and the lachrymal gland; to the mucous membrane of the nose and eyelids; to the integument of the nose, the upper eyelid, the forehead, and the upper part of the hairy scalp; and to the muscles above the middle of the circumference of the orbit. Some of the cutaneous and muscular filaments join branches of the facial nerve, and the nerve itself communicates with the sympathetic.

OPHTHALMIC GANGLION.

There are four small ganglia connected with the divisions of the fifth nerve: the ophthalmic ganglion with the first, Meckel's ganglion with the second, and the otic and submaxillary ganglia with the third. These ganglia, besides receiving branches from the sensory part of the fifth, are each connected with a motor nerve from the third, the fifth, or the facial, and with twigs from the sympathetic; and the nerves thus joining the ganglia are named their roots.

The *ophthalmic* or *lenticular* ganglion (gang. semilunare, vel ciliare) serves as a centre for the supply of nerves—motor, sensory, and sympathetic—to the eyeball. It is a small reddish body, situated at the back of the orbit, between the outer rectus muscle and the optic nerve, and generally in contact with the ophthalmic artery; it is joined behind by branches from the fifth, the third, and the sympathetic nerves; while from its fore part proceed the ciliary nerves to the eyeball.

Union of the ganglion with nerves: its roots.—The posterior border of the ganglion receives three nerves. One of these, the *long root,* a slender filament from the nasal branch of the ophthalmic trunk, joins the upper part of this border. Another branch, the *short root,* much thicker and shorter than the preceding, and sometimes divided into parts, is derived

from the branch of the third nerve to the inferior oblique muscle, and is connected with the lower part of the ganglion. The *third root* is a very small nerve which emanates from the cavernous plexus of the sympathetic, and reaches the ganglion with the long upper root : these two nerves are sometimes conjoined before reaching the ganglion. Other roots have been assigned to the ganglion. (Valentin, in Müller's Archiv. for 1840.)

Branches of the ganglion.—From the fore part of the ganglion arise ten or twelve delicate filaments—the *short ciliary nerves.* These nerves are disposed in two fasciculi, arising from the upper and lower angles of the ganglion, and they run forwards, one set above, the other below the optic nerve, the latter being the more numerous. They are accompanied by filaments from the nasal nerve (long ciliary), with which some are joined. Having entered the eyeball by apertures in the back part of the sclerotic coat, the nerves are lodged in grooves on its inner surface ; and at the ciliary muscle, which they pierce (some filaments supplying it and the cornea), they turn inwards and ramify in the iris.

SUPERIOR MAXILLARY NERVE.

The superior maxillary nerve, or second division of the fifth cranial nerve, is intermediate in size between the ophthalmic and the inferior maxillary trunks.

It commences at the middlo of the Gasserian ganglion, and, passing horizontally forwards, soon leaves the skull by the foramen rotundum of the sphenoid bone. The nerve then crosses the spheno-maxillary fossa, and enters the infra-orbital canal of the upper maxilla, by which it is conducted to the face. After emerging from the infra-orbital foramen, it terminates beneath the elevator of the upper lip in branches which spread out to the side of the nose, the eyelid, and the upper lip.

Branches.—In tho spheno-maxillary fossa a temporo-malar branch ascends from the superior maxillary nerve to the orbit, and two spheno-palatine branches descend to join Meckel's ganglion. Whilst the nerve is in contact with the upper maxilla, it furnishes two posterior dental branches on the tuberosity of the bone, and an anterior dental branch at the fore part. On the face are the terminal branches already indicated.

ORBITAL BRANCH.

The orbital or temporo-malar branch, a small cutaneous nerve, enters the orbit by the spheno-maxillary fissure, and divides into two branches (temporal and malar), which pierce the malar bone, and are distributed to the temple and the prominent part of the cheek.

a. The *temporal branch* is contained in an osseous groove or canal in the outer wall of the orbit, and leaves this cavity by a foramen in the malar bone. When about to traverse the bone, it is joined by a communicating filament (in some cases, two filaments) from the lachrymal nerve. The nerve is then inclined upwards in the temporal fossa between the bone and the temporal muscle, perforates the aponeurosis over the muscle an inch above the zygoma, and ends in cutaneous filaments over the temple. The cutaneous ramifications are united with the facial nerve, and sometimes with the superficial temporal nerve of the third division of the fifth.

b. The *malar branch* lies at first in the loose fat in the lower angle of the orbit, and is continued to the face through a foramen in the fore part of

the malar bone, where it is frequently divided into two filaments. In the prominent part of the cheek this nerve communicates with the facial nerve.

Fig. 406.

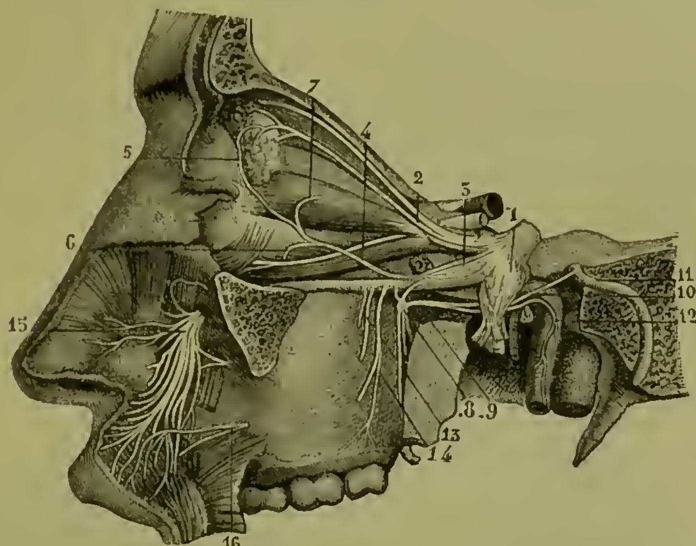


Fig. 406.—Superior Maxillary Nerve and some of the Orbital Nerves (from Sappey after Hirschfeld and Leveillé). $\frac{3}{5}$.

1, the Gasserian ganglion ; 2, lachrymal branch of the ophthalmic nerve ; 3, trunk of the superior maxillary nerve ; 4, its orbital branch, joining at 5, the palpebral twig of the lachrymal ; 6, origin of its malar twig ; 7, its temporal twig ; 8, spheno-palatine ganglion ; 9, Vidian nerve ; 10, its upper branch or great superficial petrosal nerve proceeding to join the facial nerve (11) ; 12, union of the lower branch of the Vidian nerve with the carotid branch of the sympathetic ; 13, 14, posterior dental nerves ; 15, terminal branches of the infraorbital nerves ramifying on the side of the nose and upper lip ; 16, a branch of the facial uniting with some of the twigs of the infraorbital.

POSTERIOR DENTAL BRANCHES.

The posterior dental branches, two in number, are directed downwards and outwards over the back part and tuberosity of the maxillary bone.

One of the branches enters a canal in the bone by which it is conducted to the teeth, and gives forwards a communicating filament to the anterior dental nerve. It ends in filaments to the molar teeth and the lining membrane of the maxillary sinus, and near the teeth joins a second time with the anterior dental nerve.

The *anterior* of the two branches, lying on the surface of the bone, is distributed to the gums of the upper jaw and to the buccinator muscle.

ANTERIOR DENTAL BRANCH.

The anterior dental branch, leaving the trunk of the nerve at a varying distance behind its exit from the infra-orbital foramen, enters a special canal in front of the antrum of Highmore. In this canal it receives the communicating filament from the posterior dental nerve, and divides into two branches, which furnish offsets for the front teeth.

(*a*) The *inner* branch supplies the incisor and canine teeth. Filaments from this nerve enter the lower meatus of the nose, and end in the membrane covering the lower spongy bone. Also above the root of the canine tooth, it unites with a branch of the posterior nasal nerve from Meckel's ganglion, and forms with it a small thickening,

the *ganglion of Bochdalek*, from which branches are described as descending to the alveolar process and gums of the incisor and canine teeth. (See Hyrtl's Lehrbuch, p. 804.)

(*b*) The *outer* branch gives filaments to the bicuspid teeth, and is connected with the posterior dental nerve.

INFRAORBITAL BRANCHES.

The infraorbital branches, large and numerous, spring from the end of the superior maxillary nerve beneath the elevator muscle of the upper lip, and are divisible into palpebral, nasal, and labial sets.

Fig. 407.

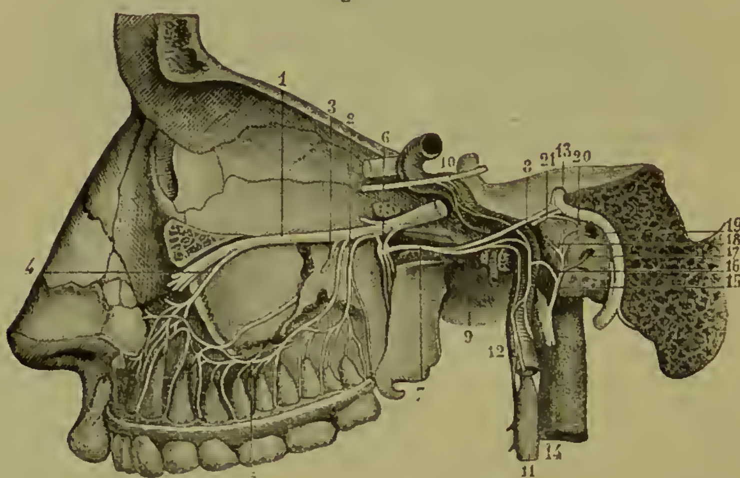


Fig. 407.—Deep View of the Spheno-Palatine Ganglion, and its Connections with other Nerves, &c. (from Sappey after Hirschfeld and Leveillé). $\frac{3}{5}$

1, superior maxillary nerve; 2, posterior superior dental; 3, second posterior dental branch; 4, anterior dental; 5, union of these nerves; 6, spheno-palatine ganglion; 7, Vidian nerve; 8, its great superficial petrosal branch; 9, its carotid branch; 10, a part of the sixth nerve, receiving twigs from the carotid plexus of the sympathetic; 11, superior cervical sympathetic ganglion; 12, its carotid branch; 13, trunk of the facial nerve near the knee or bend at the hiatus Fallopii; 14, glosso-pharyngeal nerve; 15, anastomosing branch of Jacobson; 16, twig uniting it to the sympathetic; 17, filament to the fenestra rotunda; 18, filament to the Eustachian tube; 19, filament to the fenestra ovalis; 20, external deep petrosal nerve uniting with the lesser superficial petrosal; 21, internal deep petrosal twig uniting with the great superficial petrosal.

a. The *palpebral branch* (there are sometimes two branches) turns upwards to the lower eyelid in a groove or canal of the bone, and supplies the orbicular muscle; it ends in filaments which are distributed to the eyelid in its entire breadth. At the outer angle of the eyelids this nerve is connected with the facial nerve.

b. The *nasal branches*, directed inwards to the muscles and integument of the side of the nose, communicate with the cutaneous branch of the nasal nerve.

c. The *labial*, the largest of the terminal branches of the upper maxillary nerve, and three or four in number, are continued downwards beneath the proper elevator of the upper lip. Ramifying as they descend, these nerves are distributed to the integument, the mucous membrane of the mouth, the labial glands, and the muscles of the upper lip.

Near the orbit the infraorbital branches of the superior maxillary nerve are joined by considerable branches of the facial nerve, the union between the two being named *infraorbital plexus*.

SPHENO-PALATINE GANGLION.

The spheno-palatine ganglion, frequently named Meckel's ganglion, is deeply placed in the spheno-maxillary fossa, close to the spheno-palatine foramen. It receives the two spheno-palatine branches, which descend together from the superior maxillary nerve as it crosses the top of the fossa. It is of a greyish colour, triangular in form, and convex on the outer surface. The grey or ganglionic substance does not involve all the fibres of the spheno-palatine branches of the upper maxillary nerve, but is placed at the back part, at the point of junction of the sympathetic or deep branch of the Vidian, so that the spheno-palatine nerves proceeding to the nose and palate pass to their destination without being incorporated with the ganglionic mass.

Branches proceed from the ganglion upwards to the orbit, downwards to the palate, inwards to the nose, and backwards through the Vidian and pterygo-palatine canals.

Ascending Branches.—There are three or more very small twigs, which reach the orbit by the spheno-maxillary fissure, and are distributed to the periosteum.

Bock describes a branch ascending from the ganglion to the sixth nerve; Tiedemann, one to the lower angle of the ophthalmic ganglion. The filaments described by Hirzel as ascending to the optic nerve, most probably join the ciliary twigs which surround that nerve.

Descending Branches.—These are three in number,—the large, the small, and the external palatine nerves, and are continued chiefly from the spheno-palatine branches of the superior maxillary. They are distributed to the tonsil, the hard and soft palate, the gums, and the mucous membrane of the nose.

a. The *larger* or *anterior palatine* nerve, descends in the palato-maxillary canal, and divides in the roof of the mouth into branches, which are received into grooves in the hard palate, and extend forwards nearly to the incisor teeth. In the mouth it supplies the gums, the glandular structure and the mucous membrane of the hard palate, and joins in front with the naso-palatine nerve. When entering its canal, this palatine nerve gives a nasal branch which ramifies on the middle and lower spongy bones; and a little before leaving the canal, another branch is supplied to the membrane covering the lower spongy bone: these are *inferior nasal branches*. Opposite the lower spongy bone springs a small branch, which is continued to the soft palate in a separate canal behind the trunk of the nerve.

b. The *smaller* or *posterior palatine* branch, arising near the preceding nerve, enters with a small artery the lesser palatine canal, and is conducted to the soft palate, the tonsil, and the uvula. According to Meckel, it supplies the levator palati muscle.

c. The *external palatine* nerve, the smallest of the series, courses between the upper maxilla and the external pterygoid muscle, and enters the external palatine canal between the maxillary bone and the pterygoid process of the palate bone. At its exit from the canal it gives inwards a branch to the uvula, and outwards another to the tonsil and palate. Occasionally, this nerve is altogether wanting.

Internal Branches.—These consist of the naso-palatine, and the upper and anterior nasal, which ramify in the lining membrane of the nasal fossæ and adjoining sinuses.

The *upper nasal* are very small branches, and enter the back part of the nasal fossa by the spheno-palatine foramen. Some are prolonged to the upper and posterior part of the septum, and the remainder ramify in the membrane covering

the upper two spongy bones, and in that lining the posterior ethmoid cells. A branch, as has been already stated, forms a connection in the wall of the maxillary sinus, above the eye tooth, with the anterior dental nerve.

The *naso-palatine nerve*, nerve of Cotunnius (Scarpa), long and slender, leaves the inner side of the ganglion with the preceding branches, and after crossing the roof of the nasal fossa is directed downwards and forwards on the septum nasi, towards the anterior palatine canal, situated between the periosteum and the pituitary membrane. The nerves of opposite sides descend to the palate through the mesial subdivisions of the canal, called the foramina of Scarpa, the nerve of the right side usually behind that of the left. In the lower common foramen the two naso-palatine nerves are connected with each other; and they end in several filaments, which are distributed to the papilla behind the incisor teeth, and communicate with the great palatine nerve. In its course along the septum, small filaments are furnished from the naso-palatine nerve to the pituitary membrane. (See Fig. 402. This nerve was discovered independently by John Hunter and Cotunnius; see Hunter's "Observations on certain parts of the Animal Economy;" and Scarpa, "Annotationes Anatomicæ," lib. ii.)

Fig. 408.

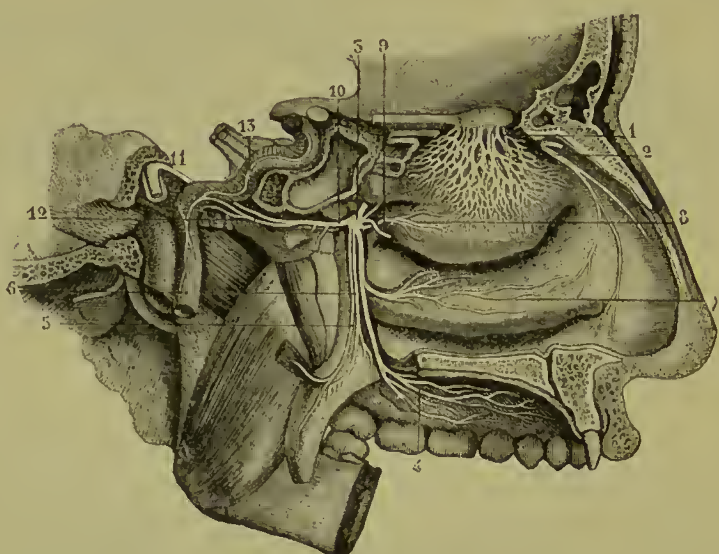


Fig. 408.—Nerves of the Nose and of the Spheno-Palatine Ganglion from the Inner Side (from Sappey after Hirschfeld and Leveillé). $\frac{2}{3}$

1, network of the branches of the olfactory nerve descending upon the membrane covering the superior and middle turbinated bones; 2, external twig of the ethmoidal branch of the nasal nerve; 3, spheno-palatine ganglion; 4, ramification of the anterior division of the palatine nerves: 5, posterior, and 6, middle divisions of the palatine nerves; 7, branch to the membrane on the lower turbinated bone; 8, branch to the superior and middle turbinated bones; 9, naso-palatine branch to the septum cut short; 10, Vidian nerve; 11, its great superficial petrosal branch; 12, its carotid branch; 13, the sympathetic nerves ascending on the internal carotid artery.

Posterior Branches.—The branches directed backwards from the spheno-palatine ganglion are the Vidian and pharyngeal nerves.

The *Vidian nerve* arises from the back part of the ganglion, which seems to be prolonged into it, passes backwards through the Vidian canal, and after emerging from this divides in the substance of the fibrocartilage filling the foramen lacerum medium, into two branches: one of these, the superficial petrosal, joins the facial nerve, while the other, the carotid branch, communicates with the sympathetic. Whilst the Vidian nerve is in its canal, it gives inwards some small *nasal* branches, which supply the membrane of the back part of the roof of the nose and septum, as well as the membrane covering the end of the Eustachian tube.

The *large superficial petrosal branch* of the Vidian nerve, entering the cranium on the outer side of the carotid artery and beneath the Gasserian ganglion, is directed backwards in a groove on the petrous portion of the temporal bone to the hiatus Fallopii, and is thus conducted to the aqueductus Fallopii, where it joins the gangliform enlargement of the facial nerve.

The *carotid* or *sympathetic portion* of the Vidian nerve, shorter than the other, is of a reddish colour and softer texture: it is directed backwards, and on the outer side of the carotid artery ends in the filaments of the sympathetic surrounding that vessel.

In accordance with the view taken of the ganglia connected with the fifth nerve (p. 599), the superficial petrosal and carotid parts of the Vidian nerve may be regarded as the motor and sympathetic roots respectively of the spheno-palatine ganglion; the spheno-palatine being its sensory root.

The *pharyngeal nerve* is inconsiderable in size, and instead of emanating directly from the ganglion, is frequently derived altogether from the Vidian. This branch, when a separate nerve, springs from the back of the ganglion, enters the pterygo-palatine canal with an artery, and is lost in the lining membrane of the pharynx behind the Eustachian tube.

Summary.—The superior maxillary nerve, with Meckel's ganglion, supplies the integument above the zygomatic arch, and that of the lower eyelid, the side of the nose, and the upper lip; the upper teeth, the lining membrane of the nose; the membrane of the upper part of the pharynx, of the antrum of Highmore, and of the posterior ethmoid cells; the soft palate, tonsil, and uvula; and the glandular and mucous structures of the roof of the mouth.

INFERIOR MAXILLARY NERVE.

The lower maxillary nerve, the third and largest division of the fifth nerve, is made up of two portions, unequal in size, the larger being derived from the Gasserian ganglion, and the smaller being the slender motor root of the fifth nerve. These two parts leave the skull by the foramen ovale in the sphenoid bone, and unite immediately after their exit. A few lines beneath the base of the skull, and under cover of the external pterygoid muscle, the nerve separates into two primary divisions, one of which is higher in position and smaller than the other.

The *small, anterior*, or *upper portion*, purely motor, terminates in branches to the temporal, masseter, buccinator, and pterygoid muscles. The *larger* or *lower* portion, chiefly sensory, divides into the auriculo-temporal, gustatory, and inferior dental branches: it likewise supplies the mylohyoid muscle, and the anterior belly of the digastric. The branch to the internal pterygoid muscle, with which also are connected those proceeding from the otic ganglion to the tensors of the palate and tympanum, is sometimes counted as a part of the larger division, but is more correctly regarded as arising from the undivided trunk.

DEEP TEMPORAL, MASSETERIC, BUCCAL, AND PTERYGOID BRANCHES.

The *deep temporal branches*, two in number, *anterior* and *posterior*, pass outwards above the external pterygoid muscle, close to the bone, and run upwards, one near the front, and the other near the back of the temporal fossa, beneath the temporal muscle in the substance of which they are distributed. (See fig. 403.)

The anterior branch is frequently joined with the buccal nerve, and sometimes with the other deep temporal branch.

The *masseteric branch* likewise passes above the external pterygoid

muscle, and is directed nearly horizontally outwards through the sigmoid notch of the lower jaw to the posterior border of the masseteric muscle, which it enters on the deep surface. It gives a filament or two to the articulation of the jaw, and occasionally furnishes a branch to the temporal muscle.

The *buccal branch* pierces the substance of the external pterygoid muscle, and courses downwards and forwards to the face, in close contact with the deep surface of the temporal muscle at its insertion. It furnishes a branch to the external pterygoid muscle as it pierces it, and on emerging gives two or three ascending branches to the temporal muscle. It divides into two principal branches, an *upper* and a *lower*, which communicate with the facial nerve in a plexus round the facial vein, and are distributed to the integument, the buccinator muscle, and the mucous membrane.

The *external pterygoid branch* is most frequently derived from the buccal nerve. It is sometimes a separate offset from the smaller portion of the lower maxillary nerve.

The *nerve* of the *internal pterygoid* muscle is closely connected at its origin with the otic ganglion, and enters the inner or deep surface of the muscle.

AURICULO-TEMPORAL NERVE.

The auriculo-temporal nerve takes its origin close to the foramen ovale. It often commences by two roots, between which may be placed the middle meningeal artery. It is directed at first backwards, beneath the external pterygoid muscle, to the inner side of the articulation of the jaw; then changing its course, it turns upwards between the ear and the joint, covered by the parotid gland; and emerging from this place, it finally divides into two temporal branches which ascend towards the top of the head.

(*a*) *Communicating branches.*—There are commonly two branches, which pass forward round the external carotid artery, and join the facial nerve. Filaments to the otic ganglion arise near the beginning of the nerve.

(*b*) *Parotid branches* are given from the nerve while it is covered by the gland.

(*c*) *Auricular branches.*—These are two in number. The *lower* of the two, arising behind the articulation of the jaw, distributes branches to the ear below the external meatus; and sends other filaments round the internal maxillary artery to join the sympathetic nerve: the *upper branch,* leaving the nerve in front of the ear, is distributed in the integument covering the tragus and the pinna above the external auditory meatus. Both are confined to the outer surface of the ear.

(*d*) *Branches to the meatus auditorius.*—These, two in number, spring from the point of connection of the facial and auriculo-temporal nerves, and enter the interior of the auditory meatus between the osseous and cartilaginous parts. One of them sends a branch to the membrana tympani.

(*e*) *Articular branch.*—The nerve to the temporo-maxillary articulation comes from one of the preceding branches, or directly from the auriculo-temporal nerve.

(*f*) *Temporal branches.*—One of these, the smaller and *posterior* of the two, distributes filaments to the anterior muscle of the auricle, the upper part of the pinna and the integument above it. The *anterior* temporal branch extends with the superficial temporal artery to the top of the head, and ends in the integument. It is often united with the temporal branch of the upper maxillary nerve. Meckel mentions a communication between this branch and the occipital nerve.

GUSTATORY NERVE.

The gustatory nerve, or lingual branch of the fifth, descends under cover of the external pterygoid muscle, lying to the inner side and in

front of the dental nerve, and sometimes united to it by a cord which crosses over the internal maxillary artery. It is there joined at an acute angle by the chorda tympani, a small branch connected with the facial nerve, which descends from the inner end of the Glaserian fissure. It then passes between the internal pterygoid muscle and the lower maxilla, and is inclined obliquely inwards to the side of the tongue, over the upper constrictor of the pharynx, (where this muscle is attached to the maxillary bone,) and above the deep portion of the submaxillary gland. Lastly, the nerve crosses Wharton's duct, and is continued along the side of the tongue to the apex, in contact with the mucous membrane of the mouth.

(*a*) *Communicating branches* are given to the submaxillary ganglion, at the place

Fig. 409.

Fig. 409.—View of the Branches of the Inferior Maxillary Nerve from the outer side (from Sappey after Hirschfeld and Leveillé). $\frac{2}{5}$

The zygoma and ramus of the jaw have been removed, and the outer plate of the jaw taken off so as to open up the dental canal; the lower part of the temporal muscle has been dissected off the bone, and the masseter muscle turned down.

1, Masseteric branch, descending to the deep surface of the muscle; 2, a twig to the temporal muscle; 5, anterior, and 7, posterior deep temporal nerves; 3, buccal; 4, its union with the facial; 6, filaments given by the buccal to the external pterygoid muscle; 8, auriculo-temporal nerve; 9, its temporal branches; 10, its anterior auricular branches; 11, its union with the facial; 12, gustatory or lingual nerve; 13, mylo-hyoid nerve; 14, inferior dental nerve; 15, its twigs supplied to the teeth; 16, mental branches; 17, branch of the facial uniting with the mental.

where the nerve is in contact with the submaxillary gland. Others form a plexus with branches of the hypoglossal nerve at the inner border of the hyoglossus muscle.

(*b*) *Branches to the mucous membrane* of the mouth are given from the nerve at the side of the tongue, and supply also the gums. Some delicate filaments are likewise distributed to the substance of the sublingual gland.

(*c*) The *lingual* or terminal branches perforate the muscular structure of the tongue, and divide into filaments, which are continued almost vertically upwards to the conical and fungiform papillæ. Near the tip of the tongue the branches of the gustatory and hypoglossal nerves are united.

INFERIOR DENTAL NERVE.

The inferior dental nerve is the largest of the three branches of the lower maxillary nerve. It descends under cover of the external pterygoid muscle, behind and to the outer side of the gustatory nerve, and passing between the ramus of the jaw and the internal lateral ligament of the temporo-maxillary articulation, enters the inferior dental canal. In company with the dental artery, it proceeds along this canal, and supplies branches to the teeth. At the mental foramen it bifurcates; one part, the incisor branch, being continued onwards within the bone to the middle line, while the other, the much larger labial branch, escapes by the foramen to the face.

When about to enter the foramen on the inner surface of the ramus of the jaw, the inferior dental nerve gives off the slender mylo-hyoid branch.

(*a*) The *mylo-hyoid branch* is lodged in a groove on the inner surface of the ramus of the maxillary bone, in which it is confined by fibrous membrane, and is distributed to the lower or cutaneous surface of the mylo-hyoideus and to the anterior belly of the digastric muscle. This nerve may be traced back within the sheath of the inferior dental to the motor portion of the inferior maxillary nerve.

(*b*) The *dental branches* supplied to the molar and bicuspid teeth correspond to the number of the fangs of those teeth. Each branch enters the minute foramen in the extremity of a fang, and terminates in the pulp of the tooth. Not unfrequently a collateral branch supplies twigs to several teeth.

(*c*) The *incisor branch* has the same direction as the trunk of the nerve: it extends to the middle line from the point of origin of the labial branch, and supplies nerves to the canine and incisor teeth.

(*d*) The *labial* or *mental branch* emerging from the bone by the foramen on the outer surface, divides beneath the depressor of the angle of the mouth into two parts:—

One of these, the outer division, communicating with the facial nerve, supplies the depressor anguli oris and orbicularis oris muscles, and the integument of the chin.

The inner portion, the larger of the two, ascends to the lower lip beneath the depressor labii inferioris muscle, to which it gives filaments: the greater number of the branches end on the inner and outer surfaces of the lip. These inner branches assist only slightly in forming the plexus of union with the facial nerve.

OTIC GANGLION.

The otic ganglion, or ganglion of Arnold, of a reddish grey colour, is situated on the deep surface of the lower maxillary trunk, nearly at the point of junction of the motor fasciculus with that nerve, and around the origin of the internal pterygoid branch. Its inner surface is close to the cartilaginous part of the Eustachian tube and the circumflexus palati muscle; and behind it is the middle meningeal artery.

Connection with nerves—roots.—The ganglion is connected with the lower maxillary nerve, especially with the branch furnished to the internal pterygoid muscle, and with the auriculo-temporal nerve, and thus obtains motor and sensory roots; it is brought into connection with the sympa-

thetic by a filament from the plexus on the middle meningeal artery. It likewise receives the *small superficial petrosal* nerve, which emerges from the petrous bone by the small foramen internal to the canal of the tensor tympani muscle, and reaches the exterior of the skull by piercing the sphenoid bone close to the foramen spinosum. By this nerve the ganglion forms a communication with the glosso-pharyngeal and facial nerves.

Fig. 410.

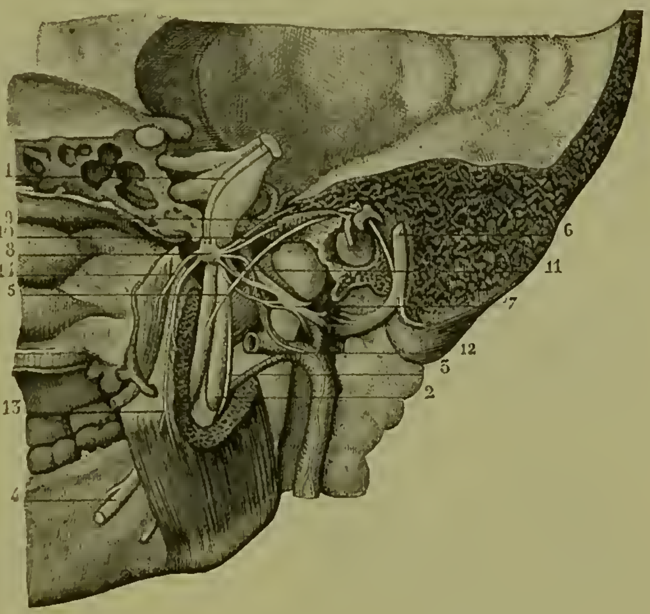


Fig. 410.—Otic Ganglion and its Connections from the inside (from Sappey after Arnold). $\frac{3}{5}$

This figure exhibits a view of the lateral portion of the skull with a part of the nasal fossa and lower jaw of the right side; the petrous bone has been removed so as to show the inner surface of the membrana tympani and the canal of the facial nerve.

1, smaller motor root of the fifth nerve passing down on the inside of the Gasserian ganglion to unite with the inferior maxillary division; 2, inferior dental nerve entering the canal of the lower jaw; 3, mylohyoid branch, seen also farther down emerging in front of the internal pterygoid muscle; 4, lingual or gustatory nerve; 5, chorda tympani; 6, facial nerve in its canal; 7, auriculo-temporal nerve, enclosing in its loop of origin the middle meningeal artery; 8, otic ganglion; 9, small superficial petrosal nerve joining the ganglion; 10, branch to the tensor tympani muscle; 11, twig connecting the ganglion with the temporo-auricular nerve; 12, twig to the ganglion from the sympathetic nerves on the meningeal artery; 13, branch to the internal pterygoid muscle; 14, branch to the tensor palati muscle.

Branches.—Two small nerves are distributed to muscles—one to the tensor of the membrane of the tympanum, the other to the circumflexus or tensor palati.

SUBMAXILLARY GANGLION.

The submaxillary ganglion is placed above the deep portion of the submaxillary gland, and is connected by filaments with the gustatory nerve. It is about the size of the ophthalmic ganglion. By the upper part or base it receives branches from nerves which may be regarded as its roots, whilst from the lower part proceed the filaments which are distributed from the ganglion.

Connection with nerves—roots.—This ganglion receives filaments from the gustatory nerve, and likewise, at its back part, a root which apparently comes from the gustatory nerve, but is in reality derived from the chorda tympani, which is prolonged downwards in the sheath of the gustatory nerve. It receives also small twigs from the sympathetic filaments on the facial artery.

Branches.—Some nerves, five or six in number, radiate to the substance

of the submaxillary gland. Others from the fore part of the ganglion, longer and larger than the preceding, end in the mucous membrane of the mouth, and in Wharton's duct.

According to Meckel ("De quinto pare," &c.), a branch occasionally descends in front of the hyo-glossus muscle, and after joining with one from the hypoglossal nerve, ends in the genio-hyo-glossus muscle.

It may be noticed that while the branches from the otic ganglion pass exclusively to muscles, the submaxillary ganglion gives no muscular offsets.

Summary.—Cutaneous filaments of the inferior maxillary nerve ramify on the side of the head, and the external ear, in the auditory passage, the lower lip, and the lower part of the face ; sensory branches are supplied by it to the greater part of the tongue ; and branches are furnished to the mucous membrane of the mouth, the lower teeth and gums, the salivary glands, and the articulation of the lower jaw.

This nerve supplies the muscles of mastication, viz., the masseter, temporal, and two pterygoid ; also the buccinator, the mylo-hyoid, and the anterior belly of the digastric ; and from the otic ganglion proceed the branches to the circumflexus palati and tensor tympani muscles.

SIXTH PAIR OF NERVES.

The sixth cranial nerve (nerv. abducens) enters the dura mater behind the dorsum sellæ, and passing forwards in the floor of the cavernous sinus, close to the outer side of the carotid artery, enters the orbit through the sphenoidal fissure, and between the heads of the external rectus muscle, and is entirely distributed to that muscle, piercing it on the ocular surface. In entering the orbit between the heads of the external rectus muscle, it is beneath the other nerves, but above the ophthalmic vein. While passing along the internal carotid artery in the cavernous sinus, it is joined by several filaments of the sympathetic from the carotid plexus. According to Bock, it is joined in the orbit by a filament from Meckel's ganglion.—("Beschreibung des Fünften Nervenpaares." 1817.)

SEVENTH PAIR OF NERVES.

In the seventh cranial nerve of Willis are comprised two nerves having a distinct origin, distribution, and function. One of these, the facial, is the motor nerve of the face ; the other, the auditory, is the special nerve of the organ of hearing. Both enter the internal auditory meatus in the temporal bone, but they are soon separated from each other.

FACIAL NERVE.

The facial nerve, or portio dura of the seventh pair, is inclined outwards with the auditory nerve, from its place of origin, to the internal auditory meatus. The facial lies in a groove on the auditory nerve, and the two are united in the auditory meatus by one or two small filaments. At the bottom of the meatus the facial nerve enters the aqueduct of Fallopius, and follows the windings of that canal to the lower surface of the skull. The nerve passes through the temporal bone at first almost horizontally outwards, between the cochlea and vestibule; on reaching the inner wall of the tym-

panum it is turned suddenly backwards above the fenestra ovalis towards the pyramid. At the place where it bends, the nerve presents a reddish *gangliform enlargement*, sometimes called the *geniculate ganglion*, which marks the place of junction of several nerves. Opposite the pyramid it is arched downwards behind the tympanum to the stylo-mastoid foramen, by which it leaves the osseous canal. It is then continued forwards through the substance of the parotid gland, and separates in the gland, behind the ramus of the lower maxilla, into two primary divisions, the temporo-facial and the cervico-facial, from which numerous branches spread out over the side of the head, the face, and the upper part of the neck, forming what is known as the "pes anserinus."

Within the temporal bone the facial is connected with several other nerves by separate branches; and immediately after issuing from the stylo-mastoid foramen, it gives off three small branches, viz., the posterior auricular, digastric, and stylo-hyoid.

Fig. 411.

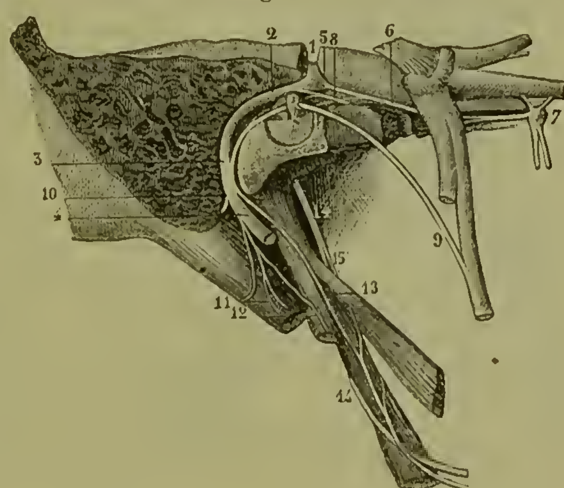


Fig. 411.—The Facial Nerve exposed in its Canal, with its Connecting Branches, &c. (from Sappey after Hirschfeld and Leveillé). $\frac{3}{5}$

The mastoid and a part of the petrous bone have been divided nearly vertically, and the canal of the facial nerve opened in its whole extent from the meatus internus to the stylo-mastoid foramen. The Vidian canal has also been opened from the outside. 1, facial nerve in the horizontal part of the commencement of the canal; 2, its second part turning backwards; 3, its vertical portion; 4, the nerve at its exit from the stylo-mastoid foramen; 5, geniculate ganglion; 6, large superficial petrosal nerve passing from this ganglion to the spheno-palatine ganglion, and joined by the small internal petrosal branch; 7, spheno-palatine ganglion; 8, small superficial petrosal nerve; 9, chorda tympani; 10, posterior auricular branch cut short at its origin; 11, branch for the digastric muscle; 12, branch for the stylo-hyoid muscle; 13, twig to the stylo-glossus muscle uniting with muscular branches of the glosso-pharyngeal nerve (14 and 15).

CONNECTING BRANCHES.

Filaments of union with the auditory nerve.—In the meatus auditorius one or two minute filaments pass between the facial and the trunk of the auditory nerve.

Nerves connected with the gangliform enlargement.—About two lines from the beginning of the aqueduct of Fallopius, where the facial nerve swells into the gangliform enlargement, it is joined by the large superficial petrosal branch from the Vidian nerve. This ganglion likewise receives a small branch from the small superficial petrosal nerve which unites the otic ganglion with the tympanic nerve of Jacobson. The nerve beyond the ganglion receives the external superficial petrosal nerve (Bidder), which is furnished by the sympathetic accompanying the middle meningeal artery, and enters the temporal bone by a canal external to that traversed by the small superficial petrosal.

CHORDA TYMPANI AND NERVE TO THE STAPEDIUS.

The nerve named chorda tympani leaves the trunk of the facial while within its canal, and crosses the tympanum to join the gustatory nerve, along which it is con-

ducted towards the tongue. It enters the back part of the tympanic cavity through a short canal emerging below the level of the pyramid, close to the ring of bone giving attachment to the membrane of the tympanum; and being invested by the mucous lining of the cavity, it is directed forwards across the membrana tympani and the handle of the malleus to an aperture at the inner end of the Glasserian fissure. It then passes downwards and forwards, under cover of the external pterygoid muscle, and uniting with the gustatory nerve at an acute angle, descends in close contact with it, and is partly distributed to the submaxillary ganglion and partly blended with the gustatory nerve in its distribution to the tongue. As this nerve crosses the tympanum, it is said to supply a twig to the laxator tympani muscle.

Fig. 412.

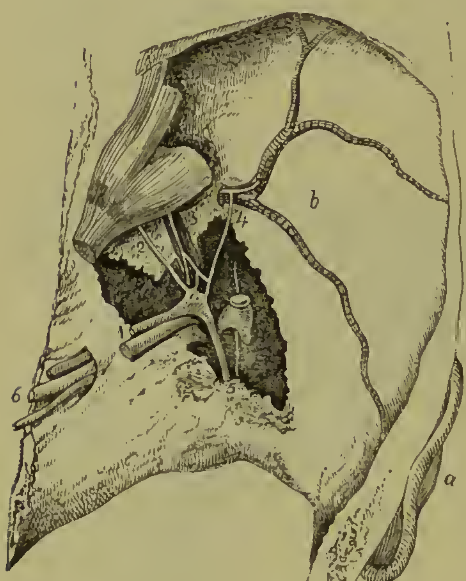


Fig. 412.—Geniculate Ganglion of the Facial Nerve and its Connections from above (from Bidder).

The dissection is made in the middle fossa of the skull on the right side; the temporal bone being removed so as to open the meatus internus, hiatus Fallopii and a part of the canal of the facial nerve, together with the cavity of the tympanum. *a*, the external ear; *b*, middle fossa of the skull with the meningeal artery ramifying in it; 1, facial and auditory nerves in the meatus auditorius internus; 2, large superficial petrosal nerve; 3, small superficial petrosal nerve lying over the tensor tympani muscle; 4, the external superficial petrosal joining sympathetic twigs on the meningeal artery; 5, facial and chorda tympani; 6, nerves of the eighth pair.

The chorda tympani is regarded by some anatomists as a continuation of the great superficial petrosal nerve. According to Owen, in the horse and calf, the portio dura being less dense in structure, the Vidian branch of the fifth may be distinctly seen crossing the nerve after penetrating its sheath, and separating into many filaments, with which filaments of the seventh nerve are blended, while a ganglion is formed by the superaddition of grey matter; and the chorda tympani is continued partly from this ganglion, partly from the portio dura. (Hunter's Collected Works, vol. iv. p. 194, note.)

The *nerve to the stapedius muscle* arises from the trunk of the facial opposite the pyramid, and passes obliquely inwards to the fleshy belly of the muscle.

POSTERIOR AURICULAR BRANCH.

This branch arises close to the stylo-mastoid foramen. In front of the mastoid process, it divides into an auricular and an occipital portion, and is connected with the great auricular nerve of the cervical plexus. It is said to be joined by the auricular branch of the pneumo-gastric nerve.

a. The *auricular division* supplies filaments to the retrahent muscle of the ear, and ends in the integument on the posterior aspect of the auricle.

b. The *occipital branch* is directed backwards beneath the small occipital nerve (from the cervical plexus) to the posterior part of the occipito-

frontalis muscle ; it lies close to the bone, and, besides supplying the muscle, gives upwards filaments to the integument.

DIGASTRIC AND STYLO-HYOID BRANCHES.

The digastric branch arises in common with that for the stylo-hyoid muscle, and is divided into numerous filaments, which enter the digastric muscle : one of these sometimes perforates the digastric, and joins the glosso-pharyngeal nerve near the base of the skull.

The stylo-hyoid branch, long and slender, is directed inwards from the digastric branch to the muscle from which it is named. This nerve is connected with the plexus of the sympathetic on the external carotid artery.

TEMPORO-FACIAL DIVISION.

The temporo-facial, the larger of the two primary divisions into which the main trunk of the facial nerve separates, is directed forwards through the parotid gland. Its ramifications and connections with other nerves form a network over the side of the face, extending as high as the temple and as low as the mouth. Its branches are arranged in temporal, malar, and infraorbital sets.

(*a*) The *temporal branches* ascend over the zygoma to the side of the head. Some end in the anterior muscle of the auricle and the integument of the temple, and communicate with the temporal branch of the upper maxillary nerve near the ear, as well as with (according to Meckel) the auriculo-temporal branch of the lower maxillary nerve. Other branches enter the occipito-frontalis, the orbicularis palpebrarum, and the corrugator supercilii muscles, and join offsets from the supraorbital branch of the ophthalmic nerve.

(*b*) The *malar branches* cross the malar bone to reach the outer side of the orbit, and supply the orbicular muscle. Some filaments are distributed to both the upper and lower eyelids: those in the upper eyelid join filaments from the lachrymal and supraorbital nerves ; and those in the lower lid are connected with filaments from the upper maxillary nerve. Filaments from this part of the facial nerve communicate with the malar branch of the upper maxillary nerve.

(*c*) The *infraorbital branches*, of larger size than the other branches, are almost horizontal in direction, and are distributed between the orbit and mouth. They supply the buccinator and orbicularis oris muscles, the elevators of the upper lip and angle of the mouth, and likewise the integument. Numerous communications take place with the fifth nerve. Beneath the elevator of the upper lip these nerves are united in a plexus with the branches of the upper maxillary nerve ; on the side of the nose they communicate with the nasal, and at the inner angle of the orbit with the infratrochlear nerve. The lower branches of this set are connected with those of the cervico-facial division.

Near its commencement the temporo-facial division of the facial is connected with the auriculo-temporal nerve of the fifth, by one or two branches of considerable size which turn round the external carotid artery ; and it gives some filaments to the tragus of the outer ear.

CERVICO-FACIAL DIVISION.

This division of the facial nerve is directed obliquely through the parotid gland towards the angle of the lower jaw, and gives branches to the face, below those of the preceding division, and to the upper part of the neck. The branches are named buccal, supramaxillary, and inframaxillary. In the gland, this division of the facial nerve is joined by filaments of the great auricular nerve of the cervical plexus, and offsets from it penetrate the substance of the gland.

(*a*) The *buccal branches* are directed across the masseter muscle to the angle of the mouth; supplying the muscles, they communicate with the temporo-facial division, and on the buccinator muscle join with filaments of the buccal branch of the lower maxillary nerve.

Fig. 413.

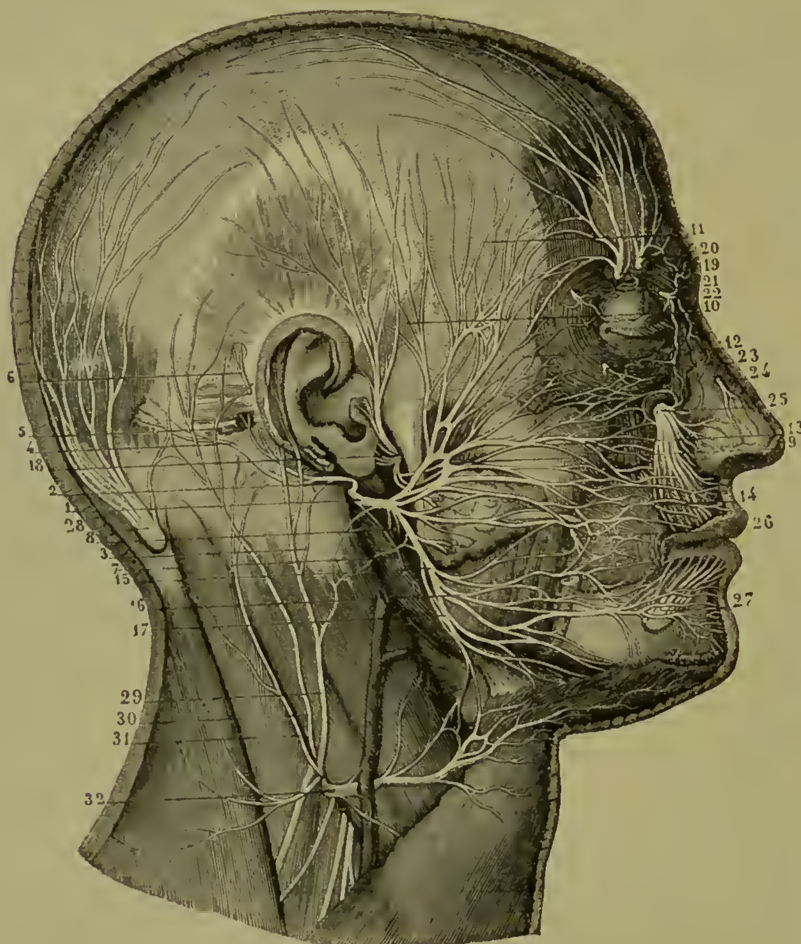


Fig. 413.—Superficial Distribution of the Facial, Trigeminal, and other Nerves of the Head (from Sappey after Hirschfeld and Leveillé). $\frac{2}{3}$

a, References to the Facial Nerve.—1, trunk of the facial nerve after its exit from the stylo-mastoid foramen; 2, posterior auricular branch; 3, filament of the great auricular nerve uniting with the foregoing; 4, twig to the occipitalis muscle; 5, twig to the posterior auricular muscle; 6, twig to the superior auricular muscle; 7, branch to the digastric; 8, that to the stylo-hyoid muscle; 9, superior or temporo-facial division of the pes anserinus; 10, temporal branches; 11, frontal; 12, palpebral or orbital; 13, nasal or infra-orbital; 14, buccal; 15, inferior or cervico-facial division of the nerve; 16, labial and mental branches; 17, cervical branches.

b, References to the Fifth Nerve.—18, temporo-auricular nerve (of the inferior maxillary nerve) uniting with the facial, giving anterior auricular and parotid branches, and ascending to the temporal region; 19, external frontal or supra-orbital nerve; 20, internal frontal; 21, palpebral twigs of the lachrymal; 22, terminal branches of the infra-trochlear; 23, malar twig of the orbito-malar; 24, external nasal twig of the ethmoidal; 25, infra-orbital nerve; 26, buccal nerve uniting with branches of the facial; 27, labial and mental branches of the inferior dental nerve.

c, Cervical Nerves.—28, great occipital nerve from the second cervical; 29, great auricular nerve from the cervical plexus; 30, lesser occipital; 31, another branch with a similar distribution; 32, superficial cervical, uniting by several twigs with the facial.

(*b*) The *supramaxillary branch*, sometimes double, gives an offset over the side of the maxilla to the angle of the mouth, and is then directed inwards, beneath the depressor of the angle of the mouth, to the muscles and integument between the lip and chin; it joins with the labial branch of the lower dental nerve.

(*c*) The *inframaxillary branches* (r. subcutanei colli), perforate the deep cervical fascia, and, placed beneath the platysma muscle, form arches across the side of the neck as low as the hyoid bone. Some branches join the superficial cervical nerve beneath the platysma, others enter that muscle, and a few perforate it to end in the integument.

Summary.—The facial nerve is the motor nerve of the face. It is distributed to most of the muscles of the ear, and to the muscles of the scalp; to those of the mouth, nose and eyelids; and to the cutaneous muscle of the neck (platysma). It likewise supplies branches to the integument of the ear, to that of the side and back of the head, as well as to that of the face and the upper part of the neck.

This nerve is connected freely with the three divisions of the fifth nerve, and with the submaxillary and spheno-palatine ganglia; with the glosso-pharyngeal and pneumo-gastric nerves; with the auditory, and with parts of the sympathetic and the spinal nerves.

AUDITORY NERVE.

The auditory nerve, or portio mollis of the seventh pair, is the special nerve of the organ of hearing, and is distributed exclusively to the internal ear.

As the auditory nerve is inclined outwards from its connection with the medulla oblongata to gain the internal auditory meatus, it is in contact with the facial nerve, being only separated from it in part by a small artery destined for the internal ear. Within the meatus the two nerves are connected to each other by one or two small filaments. Finally the auditory nerve bifurcates in the meatus: one division, piercing the anterior part of the cribriform lamina, is distributed to the cochlea; the other, piercing the posterior half of the lamina, enters the vestibule of the internal ear. The distribution of these branches will be described with the ear.

EIGHTH PAIR OF NERVES.

The eighth pair is composed of three distinct nerves—the glosso-pharyngeal, pneumo-gastric and spinal-accessory, which leave the skull through the anterior and inner division of the foramen lacerum posticum, to the inner side and in front of the internal jugular vein. Two of these nerves, the glosso-pharyngeal and pneumo-gastric, are attached to the medulla oblongata in the same line, and resemble one another somewhat in their distribution, for both are distributed to the first part of the alimentary canal. The other, the spinal-accessory, takes its origin chiefly from the spinal cord, and is mainly distributed to muscles; but it gives fibres to the first two nerves by its communicating branch.

GLOSSO-PHARYNGEAL NERVE.

The glosso-pharyngeal nerve is destined, as the name implies, for the tongue and pharynx. Directed outwards from its place of origin over the flocculus to the foramen jugulare, it leaves the skull with the pneumo-gastric and spinal-accessory nerves, but in a separate tube of dura mater. In passing through the foramen, somewhat in front of the others, this nerve is contained in a groove, or in a canal in the lower border of the petrous

portion of the temporal bone, and presents, successively, two ganglionic enlargements,—the jugular ganglion, and the petrous ganglion.

After leaving the skull, the glosso-pharyngeal nerve appears between the internal carotid artery and the jugular vein, and is directed downwards over the carotid artery and beneath the styloid process and the muscles connected with it, to the lower border of the stylo-pharyngeus muscle. Here, changing its direction, the nerve curves inwards to the tongue, on the stylo-pharyngeus and the middle constrictor muscle of the pharynx, above the upper laryngeal nerve; and, passing beneath the hyo-glossus muscle, ends in branches for the pharynx, the tonsil, and the tongue.

Fig. 414.

Fig. 414.—Diagrammatic Sketch from behind of the Roots of the Nerves of the Eighth Pair, with their Ganglia and Communications (from Bendz).

A, part of the cerebellum above the fourth ventricle; B, medulla oblongata; C, posterior columns of the spinal cord; 1, root of the glosso-pharyngeal nerve; 2, roots of the pneumo-gastric; 3, 3, 3, roots of the spinal accessory, the uppermost number indicating the filaments intermediate between the spinal accessory and pneumo-gastric; 4, jugular ganglion of the glosso-pharyngeal; 5, petrous ganglion; 6, tympanic branch; 7, ganglion of the root of the pneumo-gastric; 8, auricular branch; 9, long ganglion on the trunk of the pneumo-gastric; 10, branch from the upper ganglion to the petrous ganglion of the glosso-pharyngeal; 11, inner portion of the spinal accessory; 12, outer portion; 13, pharyngeal branch of the pneumo-gastric; 14, superior laryngeal branch; 15, twigs connected with the sympathetic; 16, fasciculus of the spinal accessory prolonged with the pneumo-gastric.

The *jugular ganglion*, the smaller of the two ganglia of the glosso-pharyngeal nerve, is situated at the upper part of the osseous groove in which the nerve is laid during its passage through the jugular foramen. Its length is from half a line to a line, and the breadth from half to three fourths of a line. It is placed on the outer side of the trunk of the nerve, and involves only a part of the fibres,—a small fasciculus passing over the ganglion, and joining the nerve below it.

The *petrous ganglion* is contained in a hollow in the lower border of the petrous part of the temporal bone (receptaculum ganglioli petrosi), and measures about three lines in length. This ganglion includes all the filaments of the nerve, and resembles the gangliform enlargement of the facial nerve. From it arise the small branches by which the glosso-pharyngeal is connected with other nerves at the base of the skull: these are the tympanic nerve, and the branches which join the pneumo-gastric and sympathetic.

CONNECTING BRANCHES, AND TYMPANIC BRANCH.

From the petrous ganglion spring three small connecting filaments. One passes to the auricular branch of the pneumo-gastric, one to the upper ganglion of the sym-

pathetic, or *vice versâ*, and a third to the ganglion of the root of the pneumo-gastric nerve. The last is not constant.

There is sometimes likewise a filament from the digastric branch of the facial nerve, which, piercing the digastric muscle, joins the glosso-pharyngeal nerve below the petrous ganglion.

The *tympanic branch* (nerve of Jacobson), arises from the petrous ganglion, and is conducted to the tympanum by a special canal, the orifice of which is in the ridge of bone between the jugular fossa and the carotid foramen. On the inner wall of the tympanum the nerve joins with a twig from the sympathetic in a plexus (tympanic), and distributes filaments to the membrane lining the tympanum and the Eustachian tube, as well as one to the fenestra rotunda, and another to the fenestra ovalis.

Fig. 415.

Fig. 415.—Sketch of the Tympanic Branch of the Glosso-Pharyngeal Nerve, and its Connections (from Breschet).

A, squamous part of the left temporal bone; B, petrous part; C, inferior maxillary nerve; D, internal carotid artery; *a*, tensor tympani muscle; 1, carotid plexus; 2, otic ganglion; 3, glosso-pharyngeal nerve; 4, tympanic nerve; 5, twigs to the carotid plexus; 6, twig to fenestra rotunda; 7, twig to fenestra ovalis; 8, junction with the large superficial petrosal nerve; 9, small superficial petrosal; 10, twig to the tensor tympani muscle; 11, facial nerve; 12, chorda tympani; 13, petrous ganglion of the glosso-pharyngeal; 14, twig to the membrane of the Eustachian tube.

From the tympanic nerve are given three *connecting branches*, by which it communicates with other nerves; and which occupy channels given off from the osseous canal through which the nerve enters the tympanum. One branch enters the carotid canal and joins with the sympathetic on the carotid artery. A second is united to the large superficial petrosal nerve, as this lies in the hiatus Fallopii. And the third is directed upwards, beneath the canal for the tensor tympani muscle, towards the surface of the petrous portion of the temporal bone, where it becomes the *small petrosal nerve*; and under this name it is continued to the exterior of the skull through a small aperture in the sphenoid and temporal bones, to end in the otic ganglion. As this petrosal nerve passes the gangliform enlargement of the facial, it has a connecting filament with that enlargement, which is by some considered its principal posterior termination.

Jacobson described an anterior or internal branch from the tympanic nerve to the spheno-palatine ganglion.

BRANCHES DISTRIBUTED IN THE NECK.

The *carotid branches* course along the internal carotid artery, and unite with the pharyngeal branch of the pneumo-gastric, and with branches of the sympathetic.

The *pharyngeal branches*, three or four in number, unite opposite the middle constrictor of the pharynx with branches of the pneumo-gastric and sympathetic to form the *pharyngeal plexus*. Nerves to the mucous membrane of the pharynx perforate the muscles, and extend upwards to the base of the tongue and the epiglottis, and downwards nearly to the hyoid bone.

The *muscular branches* are given to the stylo-pharyngeus and constrictor muscles.

Tonsillitic branches.—When the glosso-pharyngeal nerve is near the tonsil, some branches are distributed on that body in a kind of plexus (circulus tonsillaris). From these nerves offsets are sent to the soft palate and the isthmus of the fauces.

Lingual branches.—The glosso-pharyngeal nerve divides into two parts at the border of the tongue. One turns to the upper surface of the tongue, supplying the mucous membrane at its base; the other perforates the muscular structure, and ends in the mucous membrane on the lateral part of the tongue. Some filaments enter the circumvallate papillæ.

Summary.—The glosso-pharyngeal nerve distributes branches to the mucous membrane of the tongue, pharynx, tympanum and Eustachian tube. The muscles supplied by it are some of those of the pharynx and base of the tongue. It is connected with the following nerves, viz., the lower maxillary division of the fifth, the facial, the pneumo-gastric (the trunk and branches of this nerve), and the sympathetic.

PNEUMO-GASTRIC NERVE.

The pneumo-gastric nerve (nervus vagus, par vagum) has the longest course of any of the cranial nerves. It extends through the neck and the cavity of the chest to the upper part of the abdomen; and it supplies nerves to the organs of voice and respiration, to the alimentary canal as far as the stomach, and to the heart.

The filaments by which this nerve springs from the medulla oblongata are arranged in a flat fasciculus, immediately beneath the glosso-pharyngeal nerve, and directed outwards with that nerve, across the flocculus to the jugular foramen.

In passing through the opening at the base of the skull the pneumo-gastric nerve is contained in the same sheath of dura mater, and surrounded by the same tube of arachnoid membrane as the spinal-accessory nerve; but it is separated from the glosso-pharyngeal nerve by a process of membrane. In the foramen the filaments of the nerve become aggregated together; and it here presents a ganglionic enlargement, distinguished as the *ganglion of the root* of the pneumo-gastric. After its passage through the foramen, it is joined by the accessory part of the spinal-accessory nerve, and a second ganglion is formed upon it, *the ganglion of the trunk* of the nerve. Several communications are at the same time established with the surrounding nerves.

The *upper ganglion*, or *ganglion of the root* of the pneumo-gastric nerve, situated in the foramen jugulare, is of a greyish colour, nearly spherical, and about two lines in diameter; it has filaments connecting it with other nerves, viz., with the facial, the petrous ganglion of the glosso-pharyngeal, the spinal-accessory, and the sympathetic.

The *lower ganglion*, or *ganglion of the trunk* of the pneumo-gastric nerve, is about half an inch below the preceding. Occupying the trunk of the nerve outside the skull, it is of a flattened cylindrical form and reddish colour, and measures about ten lines in length and two in breadth. The ganglion does not include all the fibres of the nerve; the fasciculus, which is sent from the spinal-accessory to join the vagus, is the part not involved in the ganglionic substance. It communicates with the hypoglossal, the spinal and the sympathetic nerves.

The pneumo-gastric nerve descends in the neck, between and concealed

by the internal jugular vein and the internal carotid artery, and afterwards, similarly between that vein and the common carotid artery, being enclosed along with them in the sheath of the vessels. As they enter the thorax the nerves of the right and left side present some points of difference.

Fig. 416.

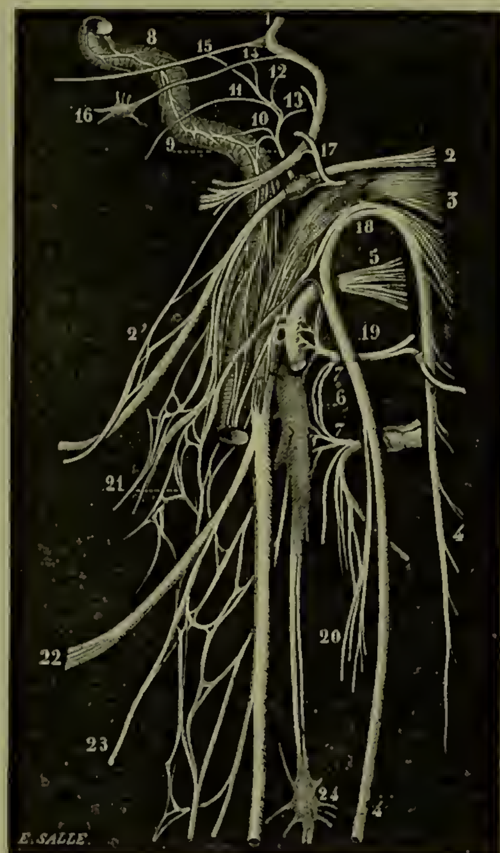


Fig. 416.—Diagram of the Roots and Anastomosing Branches of the Nerves of the Eighth Pair and Neighbouring Nerves (from Sappey after Hirschfeld and Leveillé).

1, facial nerve ; 2, glosso-pharyngeal with the petrous ganglion represented ; 2′, connection of the digastric branch of the facial nerve with the glosso-pharyngeal nerve ; 3, pneumo-gastric, with both its ganglia represented ; 4, spinal accessory ; 5, hypoglossal ; 6, superior cervical ganglion of the sympathetic ; 7, loop of union between the two first cervical nerves ; 8, carotid branch of the sympathetic ; 9, nerve of Jacobson (tympanic), given off from the petrous ganglion ; 10, its filaments to the sympathetic ; 11, twig to the Eustachian tube ; 12, twig to the fenestra ovalis ; 13, twig to the fenestra rotunda ; 14, twig of union with the small superficial petrosal ; 15, twig of union with the large superficial petrosal ; 16, otic ganglion ; 17, branch of the jugular fossa, giving a filament to the petrous ganglion ; 18, union of the spinal accessory with the pneumo-gastric ; 19, union of the hypoglossal with the first cervical nerve ; 20, union between the sterno-mastoid branch of the spinal accessory and that of the second cervical nerve ; 21, pharyngeal plexus ; 22, superior laryngeal nerve ; 23, external laryngeal ; 24, middle cervical ganglion of the sympathetic.

On the right side the nerve crosses over the first part of the right subclavian artery, at the root of the neck, and its recurrent laryngeal branch turns backwards and upwards round that vessel. The nerve then enters the thorax behind the right innominate vein, and descends on the side of the trachea to the back of the root of the lung, where it spreads out in the posterior pulmonary plexus. It emerges from this plexus in the form of two cords, which are directed to the œsophagus, and uniting and subdividing form, with similar branches of the nerve of the left side, the œsophageal plexus. Near the lower part of the œsophagus the branches, which have thus interchanged fibres with the nerve of the left side, are gathered again into a single trunk, which, descending on the back of the œsophagus, is spread out on the posterior or inferior surface of the stomach.

On the left side the pneumo-gastric nerve, entering the thorax between the left carotid and subclavian arteries and behind the left innominate vein, lies further forwards than the right nerve, and crosses over the arch of the aorta, while its recurrent laryngeal branch turns up behind the arch. It

then passes behind the root of the left lung, and, emerging from the posterior pulmonary plexus, is distributed like its fellow to the œsophagus.

Fig. 417.

Fig. 417.—View of the Nerves of the Eighth Pair, their Distribution and Connections on the Left Side (from Sappey after Hirschfeld and Leveillé). $\frac{2}{5}$

1, pneumo-gastric nerve in the neck; 2, ganglion of its trunk; 3, its union with the spinal accessory; 4, its union with the hypoglossal; 5, pharyngeal branch; 6, superior laryngeal nerve; 7, external laryngeal; 8, laryngeal plexus; 9, inferior or recurrent laryngeal; 10, superior cardiac branch; 11, middle cardiac; 12, plexiform part of the nerve in the thorax; 13, posterior pulmonary plexus; 14, lingual or gustatory nerve of the inferior maxillary; 15, hypoglossal, passing into the muscles of the tongue, giving its thyro-hyoid branch, and uniting with twigs of the lingual; 16, glosso-pharyngeal nerve; 17, spinal accessory nerve, uniting by its inner branch with the pneumo-gastric, and by its outer, passing into the sterno-mastoid muscle; 18, second cervical nerve; 19, third; 20, fourth; 21, origin of the phrenic nerve; 22, 23, fifth, sixth, seventh, and eighth cervical nerves, forming with the first dorsal the brachial plexus; 24, superior cervical ganglion of the sympathetic; 25, middle cervical ganglion; 26, inferior cervical ganglion united with the first dorsal ganglion; 27, 28, 29, 30, second, third, fourth, and fifth dorsal ganglia.

Inferiorly, it forms a single trunk in front of the œsophagus, and is spread out on the anterior or superior surface of the stomach.

There are various circumstances in the distribution of the pneumo-gastric nerves which at first sight appear anomalous, but which are explained by reference to the process of development. The recurrent direction of the inferior laryngeal branches in all probability arises from the extreme shortness or rather absence of the neck in the embryo at first, and from the branchial arterial arches having originally occupied a position at a higher level than the parts in which those branches are ultimately distributed, and having dragged them down as it were in the descent of the heart from the neck to the thorax. The recurrent direction may therefore be accepted as evidence of the development of those nerves before the occurrence of that descent. The circumstance that one recurrent laryngeal nerve passes round the subclavian artery, and the other round the aorta, is seen to arise from an originally symmetrical disposition, when it is remembered that the innominate artery and the arch of the aorta are derived from corresponding arches of the right and left sides. The supply of the back of the stomach by the right pneumo-gastric nerve, and the front by the left nerve, is connected with the originally symmetrical condition of the alimentary canal, and the turning over of the stomach on its right side in its subsequent growth.

BRANCHES OF THE PNEUMO-GASTRIC NERVE.

Some of its branches serve to connect the pneumo-gastric with other nerves, and others are distributed to the muscular substance or the mucous lining of the organs which the nerve supplies. The principal connecting branches of this nerve are derived from the ganglia. In the different stages of its course branches are supplied to various organs as follows :—In the jugular foramen, a branch is given to the ear ; in the neck branches are furnished successively to the pharynx, the larynx, and the heart ; and in the thorax additional branches are distributed to the heart, as well as to the lungs and the œsophagus. Terminal branches in the abdomen are distributed to the stomach, liver, and other organs.

CONNECTING BRANCHES AND AURICULAR BRANCH.

Connections between the upper ganglion of the vagus nerve and the spinal-accessory, glosso-pharyngeal, and sympathetic nerves.—The connection with the spinal-accessory is effected by one or two filaments. The filament to the petrous ganglion of the glosso-pharyngeal is directed transversely; it is not always present. The communication with the sympathetic is established by means of the ascending branch of the upper cervical ganglion.

The *auricular branch* is continued to the outer ear. Arising from the ganglion of the root, this branch is joined by a filament from the glosso-pharyngeal nerve, and then turns backwards along the outer boundary of the jugular foramen to an opening near the styloid process. Next, it traverses the substance of the temporal bone, crossing the aqueduct of Fallopius, about two lines from the lower end, and, reaching the surface between the mastoid process and the external auditory meatus, is distributed to the integument of the back of the ear. On the surface it joins with a twig from the posterior auricular branch of the facial nerve.

Connections of the second ganglion with the hypoglossal, sympathetic, and spinal nerves.—This ganglion is connected by filaments with the trunk of the hypoglossal, with the upper cervical ganglion of the sympathetic, and with the loop formed between the first two cervical nerves.

PHARYNGEAL BRANCH.

The pharyngeal branch arises from the upper part of the ganglion of the trunk of the nerve. In its progress inwards to the pharynx this nerve crosses, in some cases over, in others under the internal carotid artery ; and

it divides into branches which, conjointly with others derived from the glosso-pharyngeal, the superior laryngeal, and the sympathetic nerves, form a plexus (*pharyngeal*) behind the middle constrictor of the pharynx. From the plexus branches are given to the muscular structure, and to the mucous membrane of the pharynx. As the pharyngeal nerve crosses the carotid artery, it joins filaments which the glosso-pharyngeal distributes on the same vessel.—There is sometimes a second pharyngeal branch.

SUPERIOR LARYNGEAL BRANCH.

This nerve springs from the middle of the ganglion of the trunk of the pneumo-gastric nerve. It is directed inwards to the larynx beneath the internal carotid artery, and divides beneath that vessel into two branches, distinguished as external and internal laryngeal, both of which ramify in the structures of the larynx.

The *external laryngeal* branch, the smaller of the two divisions, gives backwards, at the side of the pharynx, filaments to the pharyngeal plexus and the lower constrictor muscle ; and it is finally prolonged beneath the muscles on the side of the larynx to the crico-thyroid muscle in which it ends. In the neck this branch joins the upper cardiac nerve of the sympathetic.

The *internal laryngeal* branch is continued to the interval between the hyoid bone and the thyroid cartilage, where it perforates the thyro-hyoid membrane with the laryngeal branch of the superior thyroid artery, and distributes filaments to the mucous membrane : some of these are directed upwards in the aryteno-epiglottidean fold of mucous membrane to the base of the tongue, the epiglottis, and the epiglottidean glands ; while others are reflected downwards in the lining membrane of the larynx, extending to the chorda vocalis, on the inner side of the laryngeal pouch. A slender communicating branch to the recurrent laryngeal nerve descends beneath the lateral part of the thyroid cartilage. A branch enters the arytenoid muscle, some filaments of which seem to end in the muscle, while others proceed through it to the mucous membrane.

RECURRENT LARYNGEAL BRANCH.

The recurrent or inferior laryngeal branch of the vagus nerve, as the name expresses, has a reflex course to the larynx.

The nerve on the *right side* arises at the top of the thorax, winds round the subclavian artery, and passes beneath the common carotid and inferior thyroid arteries in its course towards the trachea. On the *left side* the recurrent nerve is bent round, below and behind, the arch of the aorta, immediately beyond the point where the obliterated ductus arteriosus is connected with the arch, and is thence continued upwards to the trachea.

Each nerve in its course to the larynx is placed between the trachea and œsophagus, supplying branches to both tubes ; and each, while making its turn round the artery, gives nerves to the deep cardiac plexus. At the lower part of the cricoid cartilage the recurrent nerve distributes branches to supply all the special muscles of the larynx, except the crico-thyroid muscle, which is supplied from the upper laryngeal nerve. It likewise gives a few offsets to the mucous membrane, and a single communicating filament, which joins the long branch of the upper laryngeal nerve beneath the side of the thyroid cartilage.

CARDIAC BRANCHES.

Branches to the heart are given off by the pneumo-gastric nerve both in the neck and in the thorax.

The *cervical cardiac* branches arise at both the upper and the lower part of the neck. The *upper branches* are small, and join the cardiac nerves of the sympathetic. The *lower*, a single branch, arises as the pneumo-gastric nerve is about to enter the chest. On the right side this branch lies by the side of the innominate artery, and joins one of the cardiac nerves destined for the deep cardiac plexus; it gives some filaments to the coats of the aorta. The branch of the left side crosses tho arch of the aorta, and ends in the superficial cardiac plexus.

The *thoracic cardiac* branches of the right side leave the trunk of the pneumo-gastric as this nerve lies by the side of the trachea, and some are also derived from the first part of the recurrent branch: they pass inwards on the air-tube, and end in the deep cardiac plexus. The corresponding branches of the left side come from the left recurrent laryngeal nerve.

PULMONARY BRANCHES.

Two sets of pulmonary branches are distributed from the pneumo-gastric nerve to the lung; and they reach the root of the lung, one on its fore part, the other on its posterior aspect. The *anterior* pulmonary nerves, two or three in number, are of small size. They join with filaments of the sympathetic ramified on the pulmonary artery, and with these nerves constitute the *anterior pulmonary plexus*. Behind the root of the lung the pneumo-gastric nerve becomes flattened, and gives several branches of much larger size than the anterior branches, which, with filaments derived from the second, third, and fourth thoracic ganglia of the sympathetic, form the *posterior pulmonary plexus*. Offsets from this plexus extend along the ramifications of the air-tube through the substance of the lung.

ŒSOPHAGEAL BRANCHES.

The œsophagus within the thorax receives branches from the pneumo-gastric nerves, both above and below the pulmonary branches. The lower branches are the larger, and are derived from the *œsophageal plexus*, formed by connecting cords between the nerves of the right and left sides, while they lie in contact with the œsophagus.

GASTRIC BRANCHES.

The branches distributed to the stomach (*gastric nerves*) are the terminal branches of both pneumo-gastric nerves. The nerve of the left side, on arriving in front of the œsophagus, opposite the cardiac orifice of the stomach, divides into many branches: the largest of these extend over the fore part of the stomach; others lie along its small curvature, and unite with branches of the right nerve and the sympathetic; and some filaments are continued between the layers of the small omentum to the hepatic plexus. The right pneumo-gastric nerve descends to the stomach on the back of the gullet and distributes branches to the posterior surface of the organ: a part of this nerve is continued from the stomach to the left side of the cœliac plexus, and to the splenic plexus of the sympathetic.

Summary.—The pneumo-gastric nerves supply branches to the upper part of the alimentary canal, viz., the pharynx, œsophagus, and stomach with the liver and spleen; and to the respiratory passages, namoly, the larynx,

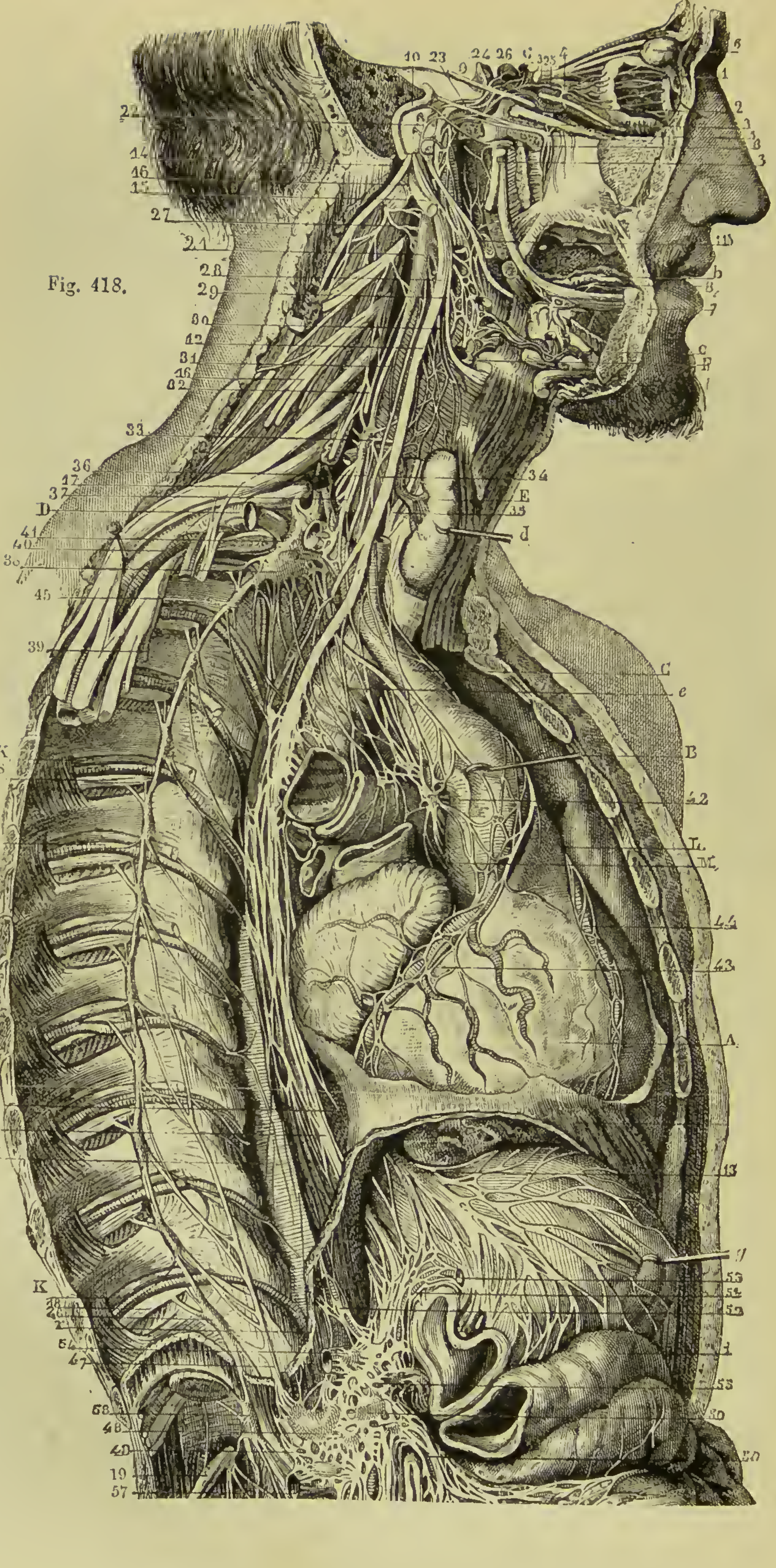


Fig. 418.

Fig. 418.—View of the Distribution and Connections of the Pneumo-gastric and Sympathetic Nerves on the Right Side (from Hirschfeld and Leveillé). $\frac{2}{5}$

a, lachrymal gland; *b*, sublingual gland; *c*, submaxillary gland and facial artery; *d*, thyroid gland, pulled forwards by a hook; *e*, trachea, below which is the right bronchus cut across; *f*, the gullet; *g*, the stomach, divided near the pylorus; *i*, transverse colon, with some folds of intestine below.

A, heart, slightly turned aside to show the cardiac plexus, &c.; B, aortic arch, drawn forward by a hook; C, innominate artery; D, subclavian artery, of which a portion has been removed to show the sympathetic ganglia; E, inferior thyroid artery; F, a divided part of the external carotid artery, upon which runs a nervous plexus; G, internal carotid emerging from its canal superiorly; H, thoracic aorta; K, intercostal vein; L, pulmonary trunk, the right branch cut; M, superior vena cava; O, intercostal artery.

1, ciliary nerves of the eyeball; 2, branch of the oculo-motor to the inferior oblique muscle, connected with the ophthalmic ganglion; 3, 3, 3, the three principal divisions of the trifacial nerve; 4, ophthalmic ganglion; 5, spheno-palatine; 6, otic; 7, submaxillary; 8, sublingual; 9, sixth nerve; 10, facial in its canal, uniting with the spheno-palatine and otic ganglia; 11, glosso-pharyngeal; 12, right pneumo-gastric; 13, left pneumo-gastric spreading on the anterior surface of the stomach; 14, spinal accessory; 15, hypoglossal; 16, upper nerve of the cervical plexus; 17, middle nerve of the brachial plexus; 18, intercostal nerves; 21, superior cervical ganglion of the sympathetic, connected with, 22, tympanic nerve of Jacobson; 23, carotid branch of the Vidian nerve; 24, cavernous plexus; 25, ophthalmic twig; 26, filament to the pituitary gland; 27, union with the upper cervical nerves; 28, points to the pneumo-gastric nerve, close to the pharyngeal and carotid branches; 29, points to the superior laryngeal nerve, close to the pharyngeal and inter-carotid plexuses; 30, laryngeal branch joining the laryngeal plexus; 31, great sympathetic nerve; 32, superior cardiac nerve; 33, middle cervical ganglion; 34, twig connecting the ganglion with, 35, the recurrent; 36, middle cardiac nerve; 37, great sympathetic nerve; 38, inferior cervical ganglion; below 37, branches from the ganglion, passing round the subclavian and vertebral arteries; 39, the line from this number crosses the nerves proceeding from the brachial plexus; 40, sympathetic twigs surrounding the axillary artery; 41, branch of union with the first intercostal nerve; the line from the letter *c*, pointing to the trachea, crosses the superior, middle, and inferior cardiac nerves; 42, cardiac plexus and ganglion; 43, 44, right and left coronary plexuses; 45, 46, thoracic portion of the great sympathetic nerve and ganglia, showing their connections with the intercostal nerves; 47, great splanchnic nerve; 48, semilunar ganglion; 49, lesser splanchnic; 50, solar plexus; 51, union with the pneumo-gastric nerve; 52, diaphragmatic plexus and ganglion; 53, coronary plexus; 54, hepatic; 55, splenic; 56, superior mesenteric; 57, renal plexus.

trachea, and its divisions in the lungs. These nerves give branches likewise to the heart and great vessels by means of their communication with the cardiac plexus. Each pneumo-gastric nerve is connected with the following cranial nerves—the spinal-accessory, glosso-pharyngeal, facial, and hypoglossal; also, with some spinal nerves; and with the sympathetic in the neck, thorax, and abdomen.

SPINAL-ACCESSORY NERVE.

The spinal nerve accessory to the vagus, or, as it is shortly named, the spinal-accessory nerve, consists of two parts: one (accessory) joins the trunk of the pneumo-gastric; the other (spinal) ends in branches to the sterno-mastoid and trapezius muscles.

The *internal or accessory part*, the smaller of the two, joins in the foramen of exit the ganglion on the root of the pneumo-gastric, by two or three filaments; and having passed from the skull, blends with the trunk of the pneumo-gastric beyond its second ganglion, as already said.

It is stated by Bendz that a filament is given from the spinal-accessory to the pharyngeal nerve above the place of junction with the pneumo-gastric, and that fibrils of the same nerve have been traced into each of the muscular offsets of the pneumo-gastric nerve. (Bendz, "Tract. de connexu inter nerv. vag. et access. 1836.")

The *external portion* of the nerve communicates with the accessory part

in the foramen jugulare. After issuing from the foramen, the nerve is directed backwards across the internal jugular vein, in some cases over, in others under it, and perforates the sterno-mastoid muscle, supplying this with branches, and joining amongst the fleshy fibres with branches of the cervical plexus. Descending in the next place across the neck behind the sterno-mastoid, the nerve passes beneath the trapezius muscle. Here it forms a kind of plexus with branches of the third and fourth cervical nerves, and distributes filaments to the trapezius, which extend nearly to the lower edge of the muscle.

NINTH PAIR OF NERVES.

The hypoglossal or ninth cranial nerve is the motor nerve of the tongue, and in part of some muscles of the neck.

The filaments by which this nerve arises from the medulla oblongata are collected into two bundles, which converge to the anterior condyloid foramen of the occipital bone. Each bundle of filaments perforates the dura mater separately within the foramen, and the two are joined after they have passed through it.

After leaving the cranium, this nerve descends almost vertically to the lower border of the digastric muscle, where, changing its course, it is directed forwards above the hyoid bone to the under part of the tongue. It lies at first very deeply with the vagus nerve, to which it is connected; but passing between the internal carotid artery and the jugular vein, it curves forward round the occipital artery, and then crosses over the external carotid below the digastric muscle. Above the hyoid bone it is crossed by the lower part of the stylo-hyoid muscle and posterior belly of the digastric, and rests on the hyo-glossus muscle. At the anterior border of the hyo-glossus it is connected with the gustatory nerve, and is continued in the fibres of the genio-hyo-glossus muscle beneath the tongue to the tip, distributing branches upwards to the muscular substance.

The principal *branches* of this nerve are distributed to the muscles ascending to the larynx and hyoid bone, and to those of the tongue; a few serve to connect it with some of the neighbouring nerves.

In animals the ninth nerve not unfrequently possesses a posterior root furnished with a ganglion, in the same manner as that of a spinal nerve.

CONNECTING BRANCHES.

Connection with the pneumo-gastric.—Close to the skull the hypoglossal nerve is connected with the second ganglion of the pneumo-gastric by separate filaments, or in some instances the two nerves are united so as to form one mass.

Union with the sympathetic and first two spinal nerves.—Opposite the first cervical vertebra the nerve communicates by several twigs with the upper cervical ganglion of the sympathetic, and with the loop uniting the first two spinal nerves in front of the atlas.

MUSCULAR AND LINGUAL BRANCHES.

Descending branch of the ninth nerve.—This branch (r. descendens noni), leaves the ninth nerve where this turns round the occipital artery, or, sometimes, higher up. It passes downwards on the surface of the sheath of the carotid vessels, gradually crossing from the outer to the inner side, gives a branch to the anterior belly of the omo-hyoid muscle, and joins about the middle of the neck in a loop with one or two branches from the second and third cervical nerves, forming the *ansa hypoglossi.* The concavity of this loop is turned upwards; and the connection between the nerves is effected by means of two or more interlacing filaments, which

enclose an irregularly-shaped space. From this interlacement of the nerves, filaments are continued backwards to the posterior belly of the omo-hyoid, and downwards to the sterno-hyoid and sterno-thyroid muscles. Occasionally a filament is continued to the chest, where it joins the cardiac and phrenic nerves.

Fig 419.

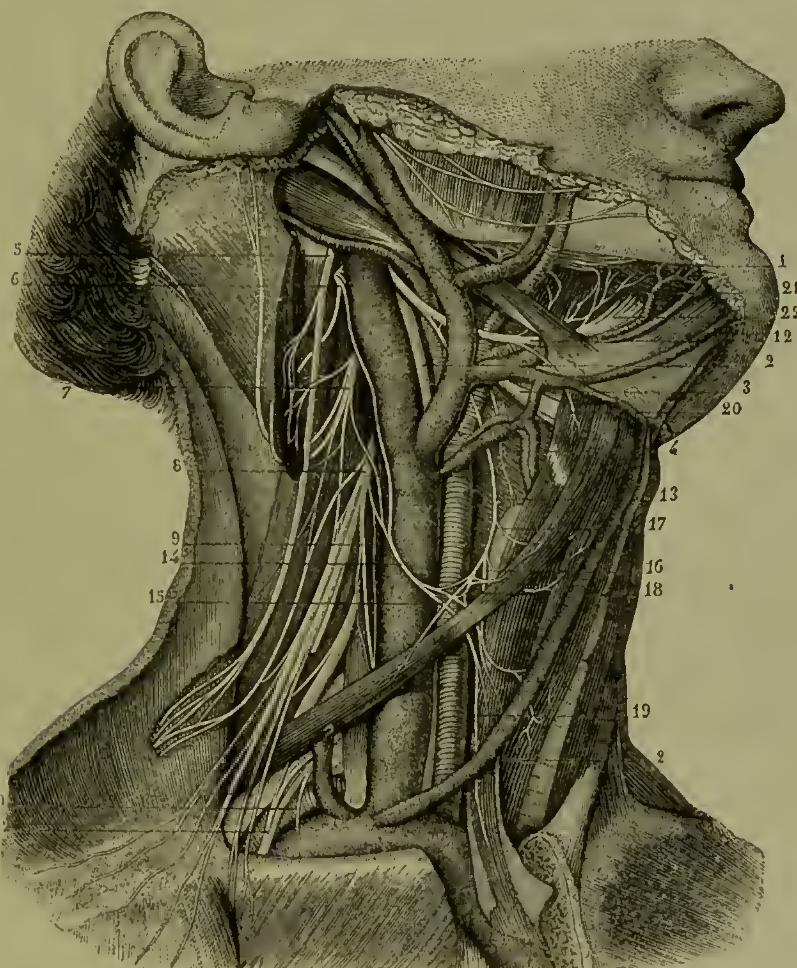


Fig. 419.—View of the Distribution of the Spinal-Accessory and Hypoglossal Nerves (from Sappey after Hirschfeld and Leveillé). $\frac{1}{2}$

1, lingual nerve ; 2, pneumo-gastric nerve ; 3, superior laryngeal (represented too large) ; 4, external laryngeal branch ; 5, spinal-accessory ; 6, second cervical ; 7, third ; 8, fourth ; 9, origin of the phrenic nerve ; 10, origin of the branch to the subclavius muscle ; 11, anterior thoracic nerves ; 12, hypoglossal nerve ; 13, its descending branch ; 14, communicating branch from the cervical nerves ; 15, 16, 18, 19, descending branches from the plexiform union of these nerves to the sterno-hyoid, sterno-thyroid, and omo-hyoid muscles ; 17, branch from the descendens noni to the upper belly of the omo-hyoid muscle ; 20, branch from the hypoglossal nerve to the thyro-hyoid muscle ; 21, communicating twigs from the hypoglossal to the lingual nerve ; 22, terminal distribution of the hypoglossal to the muscles of the tongue.

It is not uncommon to find the descending branch of the ninth nerve within the sheath of the large cervical vessels, and in such cases it is placed either over or under the vein. This nerve in some cases appears to be derived either altogether from the pneumo-gastric, or from both the pneumo-gastric and hypoglossal nerves. There is every reason, however, to believe that these varieties in origin are only apparent, arising from the temporary adhesion of the filaments of this branch to those of the

pneumo-gastric. It is probable, moreover, that the descendens noni has little if any real origin from the hypoglossal nerve: Luschka states it as the result of numerous researches on the human subject that the descendens noni usually contains no filaments from the hypoglossal, but is a branch from the first and second cervical, temporarily associated with the ninth nerve; and this quite agrees with the circumstance that in the domestic animals the branches supplied to those muscles to which the descendens noni of the human subject is distributed come from the cervical plexus.

Branches to muscles and the tongue.—The branch to the thyro-hyoid muscle is a separate twig given off from the hypoglossal nerve as it approaches the hyoid bone. The nerve supplies branches to the stylo-hyoid, hyo-glossus, genio-hyoid, and genio-hyo-glossus muscles as it becomes contiguous to each, and when arrived close to the middle of the tongue with the ranine artery, gives off several long slender branches, which pass upwards into the substance of the organ. Some filaments join with others proceeding from the gustatory nerve.

A branch is described as uniting with its fellow of the opposite side, in the substance of the genio-hyoid muscle or between it and the genio-glossus. This loop, as also the ansa hypoglossi, is recommended by Hyrtl as a particularly favourable example for the observation of nerve fibres returning to the nervous centres without distribution, to which he gives the name of "nerves without ends." ("Nat. Hist. Review, Jan. 1862.") That in the ansa hypoglossi an interchange of fibres takes place, so that a filament of the spinal nerve is directed upwards along the branch of the hypoglossal, and *vice versâ*, was noticed by Cruveilhier.

Summary.—The hypoglossal nerve supplies, either alone or in union with branches of the spinal nerves, all the muscles connected with the os hyoides, including those of the tongue, with the exception of the digastric and stylo-hyoid, the mylo-hyoid and the middle constrictor of the pharynx. It also supplies the sterno-thyroid muscle.

It is connected with the following nerves, viz., pneumo-gastric, gustatory, three upper cervical nerves, and the sympathetic.

B. SPINAL NERVES.

The spinal nerves are characterised by their origin from the spinal cord, and their direct transmission outwards from the spinal canal in the intervals between the vertebræ. Taken together these nerves consist of thirty-one pairs; and, according to the region in which they issue from the spinal canal, they are named cervical, dorsal, lumbar, sacral, and coccygeal.

By universal usage each pair of nerves in the dorsal, lumbar, and sacral regions is named in correspondence with the vertebra beneath which it emerges. There are thus left eight pairs of nerves between the cranium and the first dorsal nerve, the first being placed above the atlas and the eighth below the seventh cervical vertebra, which are reckoned by the majority of writers as eight cervical nerves. The nerves of the thirty-first pair emerge from the lower end of the sacral canal, below the first vertebra of the coccyx, and are named coccygeal.

Although the plan of counting eight cervical nerves is continued in this work for the sake of convenience, it being that which is most frequently followed, it is by no means intended to represent this method as scientifically correct. The plan of Willis, who reckoned the suboccipital as a cranial nerve had at least the advantage that it made the numbers of the remaining seven cervical nerves correspond each with the vertebra beneath which it emerged, as do the dorsal, lumbar and sacral nerves; and if the suboccipital nerve, while recognised as the first spinal nerve, be

kept distinct from the seven which succeed, as is taught in some schools, a nomenclature is arrived at much less objectionable than that which is most prevalent. A reference, however, to development (p. 17) will remind the reader that in the primordial vertebræ each spinal nerve is originally situated above the rib and transverse process belonging to the same segment; and it will become apparent that the scientifically accurate nomenclature of nerves might be rather to name each in accordance with the number of the vertebra below it. Thus the eighth cervical nerve would be called first dorsal, and so on.

Fig 420.

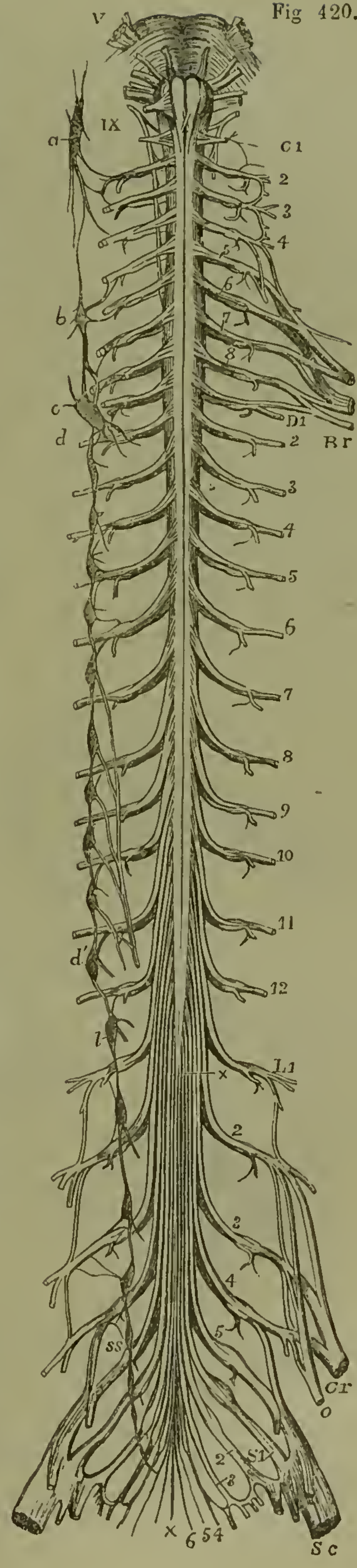


Fig. 420.—Diagrammatic Outline of the Roots and First Part of the Spinal Nerves, together with the Sympathetic Cord of one side. $\frac{1}{4}$

The view is taken from before. In the upper part of the figure the pons Varolii and medulla oblongata are represented, and from V, to IX, the roots of the several cranial nerves from the trifacial to the hypoglossal are indicated. On the left side C1, is placed opposite the first cervical or suboccipital nerve; and the numbers 2 to 8 following below indicate the corresponding cervical nerves; Br, indicates the brachial plexus; D1, is placed opposite the intercostal part of the first dorsal nerve, and the numbers 2 to 12 following mark the corresponding dorsal nerves; L1, the first lumbar nerve, and the numbers 2 to 5 following the remaining lumbar nerves; Cr, the anterior crural, and *o*, the obturator nerve; S1, the first sacral, and the following numbers 2 to 5, the remaining sacral nerves; 6, the coccygeal nerve; Sc, the great sciatic nerve; ×, ×, the filum terminale of the cord.

On the right side of the figure the following letters indicate parts of the sympathetic nerves; viz. *a*, the superior cervical ganglion, communicating with the upper cervical spinal nerves and continued below in the great sympathetic cord; *b*, the middle cervical ganglion; *c*, *d*, the lower cervical ganglion united with the first dorsal; *d′*, the eleventh dorsal ganglion; from the fifth to the ninth dorsal ganglia the origins of the great splanchnic nerve are shown; *l*, the lowest dorsal or upper lumbar ganglion; *ss*, the upper sacral ganglion. In the whole extent of the sympathetic cord, the twigs of union with the spinal nerves are shown.

Sometimes an additional coccygeal nerve exists. Among seven cases which appear to have been examined with great care, Professor Schlemm ("Observat. Neurologicæ," Berolini, 1834) found two coccygeal nerves on each side in one instance, and on one side in another case. In all the rest there was only a single coccygeal nerve on each side.

THE ROOTS OF THE SPINAL NERVES.

Each spinal nerve springs from the spinal cord by two roots which approach one another, and, as they quit the spinal canal, join in the corresponding intervertebral foramen into a single cord; and each cord so formed separates immediately into two divisions one of which is destined for parts in front of the spine, the other for parts behind it.

The *posterior roots* of the nerves are distinguished from the anterior roots by their greater size, as well as by the greater thickness of the fasciculi of which they are composed. Each spinal nerve is furnished with a ganglion; but the first cervical or sub-occipital nerve is in some cases without one. The size of the ganglia is in proportion to that of the nerves on which they are formed.

The ganglia are in general placed in the intervertebral foramina, immediately beyond the points at which the roots perforate the dura mater lining the spinal canal. The first and second cervical nerves, however, which leave the spinal canal over the laminæ of the vertebræ, have their ganglia opposite those parts. The ganglia of the sacral nerves are contained in the spinal canal, that of the last nerve being occasionally at some distance from the point at which the nerve issues. The ganglion of the coccygeal nerve is placed within the canal in the sac of dura mater, and at a variable distance from the origin of the nerve.

Fig. 421.

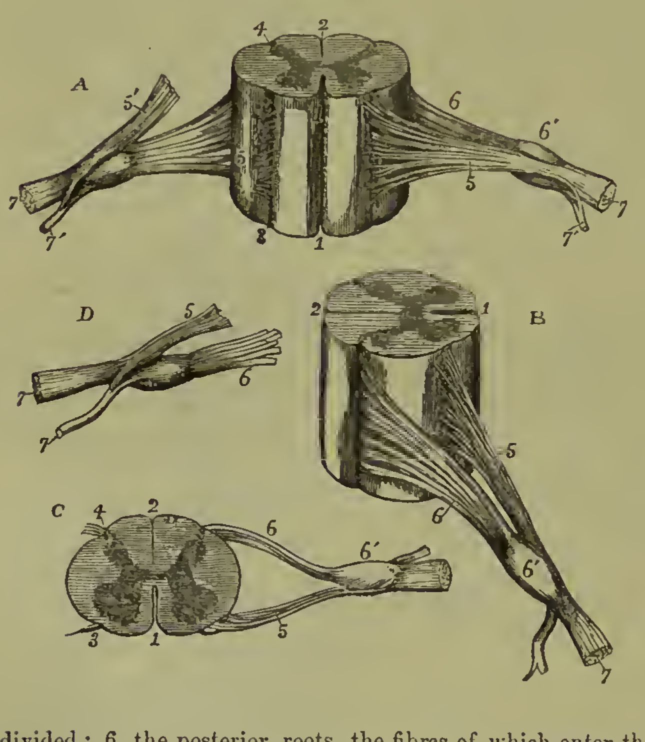


Fig. 421.—Different Views of a Portion of the Spinal Cord from the Cervical Region with the Roots of the Nerves. Slightly enlarged.

In A, the anterior surface of the specimen is shown, the anterior nerve-root of the right side being divided; in B, a view of the right side is given; in C, the upper surface is shown; in D, the nerve-roots and ganglion are shown from below. 1, the anterior median fissure; 2, posterior median fissure; 3, anterior lateral depression, over which the anterior nerve-roots are seen to spread; 4, posterior lateral groove, into which the posterior roots are seen to sink; 5, anterior roots passing the ganglion; 5′, in A, the anterior root divided; 6, the posterior roots, the fibres of which enter the ganglion, 6′; 7, the united or compound nerve; 7′, the posterior primary branch seen in A and D, to be derived in part from the anterior and in part from the posterior root.

The fibres of the posterior root of the nerve divide into two bundles as they approach the ganglion, and the inner extremity of the oval-shaped ganglion is sometimes bilobate, the lobes corresponding to the two bundles of fibres.

These fibres in man and the mammalia appear to pass through the ganglion without union with its cells. The cells are both unipolar and bipolar, but the fibres connected with them all pass to the periphery (Kölliker), so that beyond the ganglion the posterior root of the nerve has received an additional set of fibres besides those which it contains before reaching the ganglion. In fishes, on the contrary, all the fibres of the posterior root are connected with the opposite extremities of the bipolar cells of the ganglion.

The *anterior roots* of the spinal nerves are, as will be inferred from what has been already stated, the smaller of the two; they are devoid of ganglionic enlargement, and their fibres are collected into two bundles near the intervertebral ganglion, as in the posterior root.

Size.—The roots of the upper *cervical nerves* are smaller than those of the lower nerves, the first being much the smallest. The posterior roots of these nerves exceed the anterior in size more than in the other spinal nerves, and they are likewise composed of fasciculi which are considerably larger than those of the anterior roots.

The roots of the *dorsal nerves*, exception being made of the first, which resembles the lowest cervical nerves and is associated with them in a part of its distribution, are of small size, and vary but slightly, or not at all, from the second to the last. The fasciculi of both roots are thinly strewed over the spinal cord, and are slender, those of the posterior exceeding in thickness those of the anterior root in only a small degree.

The roots of the lower *lumbar*, and of the upper *sacral nerves*, are the largest of all the spinal nerves; those of the lowest sacral and the coccygeal nerve are, on the other hand, the slenderest. All these nerves are crowded together round the lower end of the cord. Of these nerves the anterior roots are the smaller, but the disproportion between the anterior and posterior roots is not so great as in the cervical nerves.

Length of the nerves in the spinal canal.—The place at which the roots of the upper cervical nerves are connected with the spinal cord being nearly opposite the foramina by which they respectively leave the canal, these roots are comparatively short. But the distance between the two points referred to is gradually augmented from nerve to nerve downwards, so that the place of origin of the lower cervical nerves is the breadth of at least one vertebra, and that of the lower dorsal nerves about the breadth of two vertebræ above the foramina by which they respectively emerge from the canal. Moreover, as the spinal cord extends no farther than the first lumbar vertebra, the length of the roots of the lumbar, sacral, and coccygeal nerves increases rapidly from nerve to nerve, and in each case may be estimated by the distance of the foramen of exit from the extremity of the cord. Owing to their length, and the appearance they present in connection with the spinal cord, the aggregation of the roots of the nerves last referred to has been named the "cauda equina."

The direction the roots take within the canal requires brief notice. The first cervical nerve is directed horizontally outwards. The roots of the lower cervical and dorsal nerves at first descend over the spinal cord, held in contact with it by the arachnoid, till they arrive opposite the several intervertebral foramina, where they are directed horizontally outwards. The nerves of the cauda equina run in the direction of the spinal canal.

Division of the nerves.—The two roots of each of the spinal nerves unite immediately beyond the ganglion, and the trunk thus formed separates, as already mentioned, into two divisions, an anterior and a posterior, which are called primary branches or divisions.

In the detailed description of the spinal nerves which follows, we shall

begin with their posterior primary divisions, calling attention first to certain characters common to the whole of them, and afterwards stating separately the arrangement peculiar to each group of nerves (cervical, dorsal, &c.).

POSTERIOR PRIMARY DIVISIONS

OF THE SPINAL NERVES.

The posterior divisions of the spinal nerves are, with few exceptions, smaller than those given to the fore part of the body. Springing from the trunk which results from the union of the roots of the nerve in the intervertebral foramen, or frequently by separate fasciculi from each of the roots, each turns backwards at once, and soon divides into two parts, distinguished as *external* and *internal*, distributed to the muscles and the integument behind the spine. The first cervical, the fourth and fifth sacral and the coccygeal nerve are the only nerves the posterior divisions of which do not separate into external and internal branches.

The Suboccipital Nerve.—The posterior division of the suboccipital nerve, which is the larger of the two primary divisions, emerging over the arch of the atlas, between this and the vertebral artery, enters the space bounded by the larger rectus and the two oblique muscles, and divides into branches for the surrounding muscles.

a. One branch descends to the lower oblique muscle and gives a filament, through or over the fibres of that muscle, to join the second cervical nerve.

b. Another ascends over the larger rectus muscle, supplying it and the smaller rectus.

c. A third enters the upper oblique muscle.

d. A fourth sinks into the complexus, where that muscle covers the nerve and its branches.

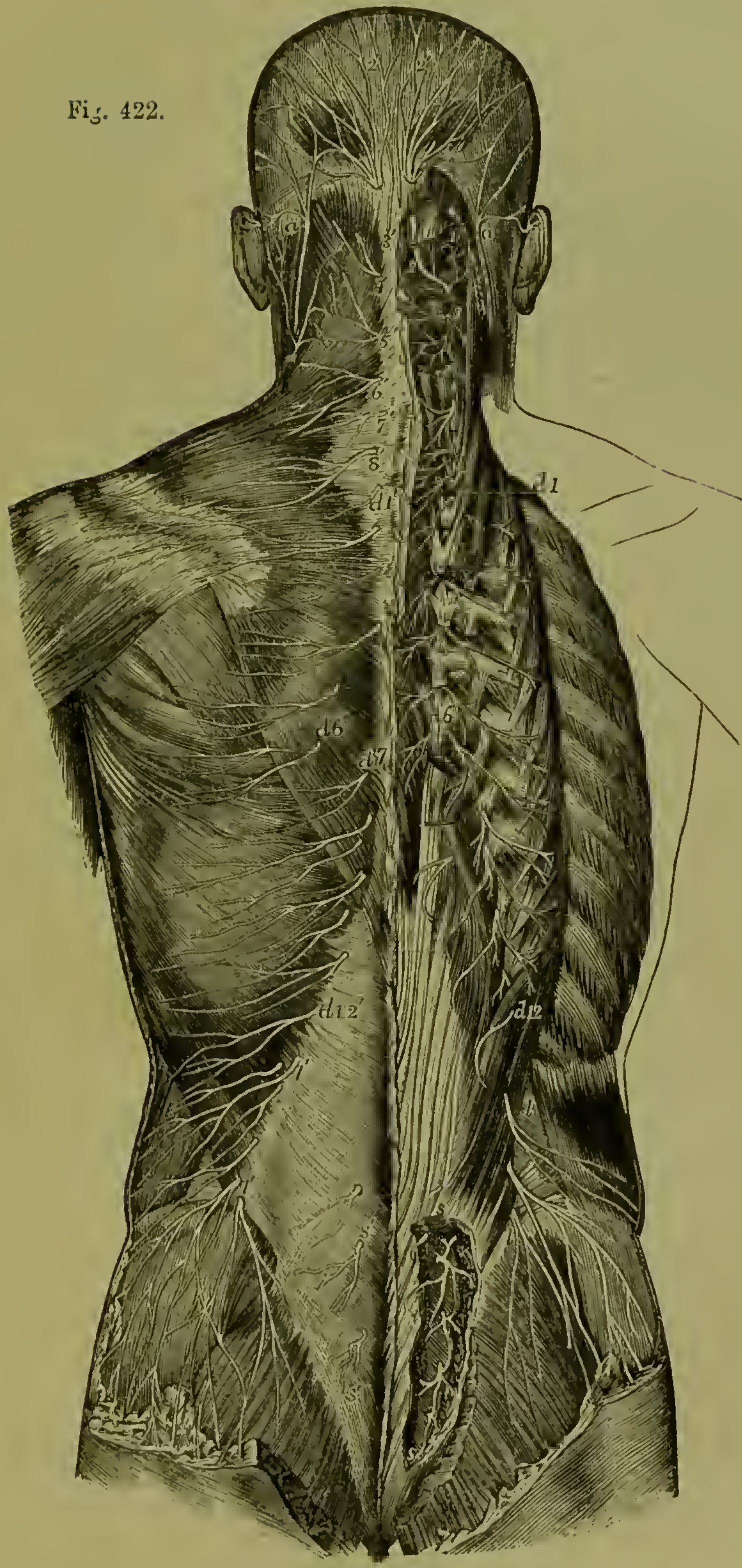
A *cutaneous branch* is occasionally given to the back of the head; it accompanies the occipital artery, and is connected beneath the integument with the great and small occipital nerves.

Fig. 422.—Superficial and Deep Distribution of the Posterior Primary Divisions of the Spinal Nerves (from Hirschfeld and Leveillé). ½

On the left side the cutaneous branches are represented as lying upon the superficial layer of muscles; on the right side, the superficial muscles having been removed, the splenius and complexus have been divided in the neck, and the erector spinæ separated and partially removed in the back, so as to expose the deep issue of the nerves.

a, *a*, lesser occipital nerve from the cervical plexus; 1, external muscular branches of the first cervical nerve and union by a loop with the second; 2, placed on the rectus capitis posticus major, marks the great occipital nerve passing round the short muscles and piercing the complexus: the external branch is seen to the outside; 2′, cranial distribution of the great occipital; 3, external branch of the posterior primary division of the third nerve; 3′, its internal branch, or third occipital nerve; 4′, 5′, 6′, 7′, 8′, internal branches of the several corresponding nerves on the left side: the external branches of these nerves proceeding to muscles are displayed on the right side; *d*1, to *d* 6, and thence to *d* 12, external muscular branches of the posterior primary divisions of the twelve dorsal nerves on the right side; *d* 1′, to *d* 6′, the internal cutaneous branches of the six upper dorsal nerves on the left side; *d* 7′, to *d* 12′, cutaneous branches of the six lower dorsal nerves from the external branches; *l*, *l*, external branches of the posterior primary branches of several lumbar nerves on the right side piercing the muscles, the lower descending over the gluteal region; *l*′, *l*′, the same more superficially on the left side; *s*, *s*, on the right side, the issue and union by loops of the posterior primary divisions of four sacral nerves; *s*′, *s*′, some of these distributed to the skin on the left side.

Fig. 422.



Cervical Nerves, *with the exception of the suboccipital.*—The *external branches* give only muscular offsets, and are distributed to the splenius and the slender muscles prolonged to the neck from the erector spinæ, viz., the

cervicalis ascendens, and the transversalis colli with the trachelo-mastoid. That of the second nerve is the largest of the series of external branches, and is often united to the corresponding branch of the third ; it supplies the complexus muscle which covers it, and ends in the splenius and trachelo-mastoid muscles.

The *internal branches*, larger than the external, are differently disposed at the upper and the lower parts of the neck. That of the second cervical nerve is named, from its size and destination, the *great occipital*, and requires separate notice. The rest are directed inwards to the spinous processes of the vertebræ. Those derived from the third, fourth, and fifth nerves pass over the semispinalis and beneath the complexus muscle, and, having reached the spines of the vertebræ, turn transversely outwards and are distributed in the integument over the trapezius muscle. From the cutaneous branch of the third nerve a branch passes upwards to the integument on the lower part of the occiput, lying at the inner side of the great occipital nerve, and is sometimes called third occipital nerve.

Between the inner branches of the first three cervical nerves, beneath the complexus, there are frequently communicating fasciculi; and this communication Cruveilhier has designated as "the posterior cervical plexus."

The internal branches from the lowest three cervical nerves are placed beneath the semispinalis muscle, and end in the muscular structure, without furnishing (except occasionally the sixth) any offset to the skin. These three nerves are the smallest of the series.

The *great occipital nerve* is directed upwards on the lower oblique muscle, and is transmitted to the surface through the complexus and trapezius muscles, giving twigs to the complexus. Ascending with the occipital artery, it divides into branches, which radiate over the occipital part of the occipito-frontalis muscle, some appearing to enter the muscle, and others joining the smaller occipital nerve.

An *auricular branch* is sometimes supplied to the back of the ear by the great occipital nerve.

Dorsal Nerves.—The *external branches* increase in size from above downwards. They are directed through or beneath the longissimus dorsi to the space between that muscle and the ilio-costalis and accessory ; they supply both those muscles, together with the small muscles continued upwards from the erector spinæ to the neck, and also the levatores costarum. The lower five or six nerves give cutaneous twigs, which are transmitted to the integument in a line with the angles of the ribs.

The *internal branches* of the upper six dorsal nerves appear in the interval between the multifidus spinæ and the semi-spinalis dorsi ; they supply those muscles, and become cutaneous by the side of the spinous processes of the vertebræ. The cutaneous branch from the second nerve, and sometimes others, reach as far as the scapula. The internal branches of the lower six dorsal nerves are placed between the multifidus spinæ and longissimus dorsi, and end in the multifidus without giving branches to the integument. Where cutaneous nerves are supplied by the internal branches, there are none from the external branches of the same nerve, and *vice versâ*.

Lumbar Nerves.—The *external branches* enter the erector spinæ, and give filaments to the intertransverse muscles. From the upper three, cutaneous nerves are supplied; and from the last, a fasciculus descends to the corresponding branch of the first sacral nerve.—The *cutaneous nerves* given from the external branches of the first three lumbar nerves, pierce the

fleshy part of the ilio-costalis, and the aponeurosis of the latissimus dorsi; they cross the iliac crest near the edge of the erector spinæ, and terminate in the integument of the gluteal region. One or more of the filaments may be traced as far as the great trochanter of the femur.

The *internal branches* wind backwards in grooves close to the articular processes of the vertebræ, and sink into the multifidus spinæ muscle.

Sacral Nerves.—The posterior divisions of these nerves, except the last, issue from the sacrum through its posterior foramina. The first three are covered at their exit from the bone by the multifidus spinæ muscle, and bifurcate like the posterior trunks of the other spinal nerves; but the remaining two, which continue below that muscle, have a peculiar arrangement, and require separate examination.

The *internal branches of the first three* sacral nerves are small, and are lost in the multifidus spinæ muscle.

The *external branches* of the same nerves are united with one another, and with the last lumbar and fourth sacral nerves, so as to form a series of anastomotic loops on the upper part of the sacrum. These branches are then directed outwards to the cutaneous or posterior surface of the great sacro-sciatic ligament, where, covered by the gluteus maximus muscle, they form a second series of loops, and end in cutaneous nerves. These pierce the great gluteus muscle in the direction of a line from the posterior iliac spine to the tip of the coccyx. They are commonly three in number—one is near the innominate bone, another opposite the extremity of the sacrum, and the third about midway between the other two. All are directed outwards over the great gluteal muscle.

In six dissections by Ellis this arrangement was found to be the most frequent. The variations to which it is liable are these:—the first nerve may not take part in the second series of loops, and the fourth may be associated with them.

The posterior divisions of the *last two sacral nerves* are smaller than those above them, and are not divided into external and internal branches. They are connected with each other by a loop on the back of the sacrum, and the lowest is joined in a similar manner with the coccygeal nerve; one or two small filaments from these sacral nerves are distributed behind the coccyx.

Coccygeal Nerve.—The posterior division of the coccygeal nerve is very small, and separates from the anterior primary portion of the nerve in the sacral canal. It is joined by a communicating filament from the last sacral nerve, and ends in the fibrous structure covering the posterior surface of the coccyx.

ANTERIOR PRIMARY DIVISIONS

OF THE SPINAL NERVES.

The anterior primary divisions of the spinal nerves are distributed to the parts of the body situated in front of the vertebral column, including the limbs. They are, for the most part, considerably larger than the posterior divisions.

The anterior division of each spinal nerve is connected by one or two slender filaments with the sympathetic. Those of the cervical, lumbar, and sacral nerves form plexuses of various forms; but those of the dorsal nerves remain for the most part separate one from another.

CERVICAL NERVES.

The anterior divisions of the four upper cervical nerves form the cervical plexus. They appear at the side of the neck between the scalenus medius and rectus anticus major muscles. They are each connected by a communicating filament with the first cervical ganglion of the sympathetic nerve, or with the cord connecting that ganglion with the second.

The anterior divisions of the four lower cervical nerves, larger than those of the upper four, appear between the scaleni muscles, and, together with that of the first dorsal, go to form the brachial plexus. They are each connected by a filament with one of the two lower cervical ganglia of the sympathetic, or with the plexus on the vertebral artery.

The anterior divisions of the first and second nerves require a notice separately from the description of the nerves of the cervical plexus.

SUBOCCIPITAL NERVE.

The anterior primary division of the first nerve runs forwards in a groove on the atlas, and bends downwards in front of the transverse process of that vertebra to join the second nerve. In this course forwards it lies beneath the vertebral artery, and at the inner side of the rectus lateralis muscle, to which it gives a branch. As it crosses the foramen in the transverse process of the atlas, the nerve is joined by a filament from the sympathetic; and from the arch, or *loop of the atlas*, which it makes in front of the transverse process, branches are supplied to the two anterior recti muscles. Short filaments connect this part of the nerve with the pneumo-gastric, the hypoglossal, and the sympathetic nerves.

Valentin notices filaments distributed to the articulation of the occipital bone with the atlas, and to the mastoid process of the temporal bone.

SECOND CERVICAL NERVE.

The anterior division of the second cervical nerve, beginning between the arches of the first two vertebræ, is directed forwards between their transverse processes, being placed outside the vertebral artery, and beneath the intertransverse and other muscles fixed to those processes. In front of the intertransverse muscles the nerve divides into an ascending part, which joins the first cervical nerve, and a descending part to the third.

CERVICAL PLEXUS.

The cervical plexus is formed by the anterior divisions of the first four cervical nerves, and distributes branches to some of the muscles of the neck, and to a portion of the integument of the head and neck. It is placed opposite the first four vertebræ, beneath the sterno-mastoid muscle, and rests against the middle scalenus muscle and the levator anguli scapulæ. The disposition of the nerves in the plexus is easily recognised. Each nerve, except the first, branches into an ascending and a descending part: and these are united in communicating loops with the contiguous nerves. From the union of the second and third nerves, superficial branches are supplied to the head and neck; and from the junction of the third with the fourth, arise the cutaneous nerves of the shoulder and chest. Muscular and communicating branches spring from the same nerves.

The *branches* of the plexus may be separated into two sets—a superficial

and deep; the superficial consisting of those which ramify over the cervical fascia, supplying the integument and some also the platysma; the deep comprising branches which are distributed for the most part to the muscles. The superficial nerves may be subdivided into ascending and descending; the deep nerves into an internal and external series.

Fig. 423.

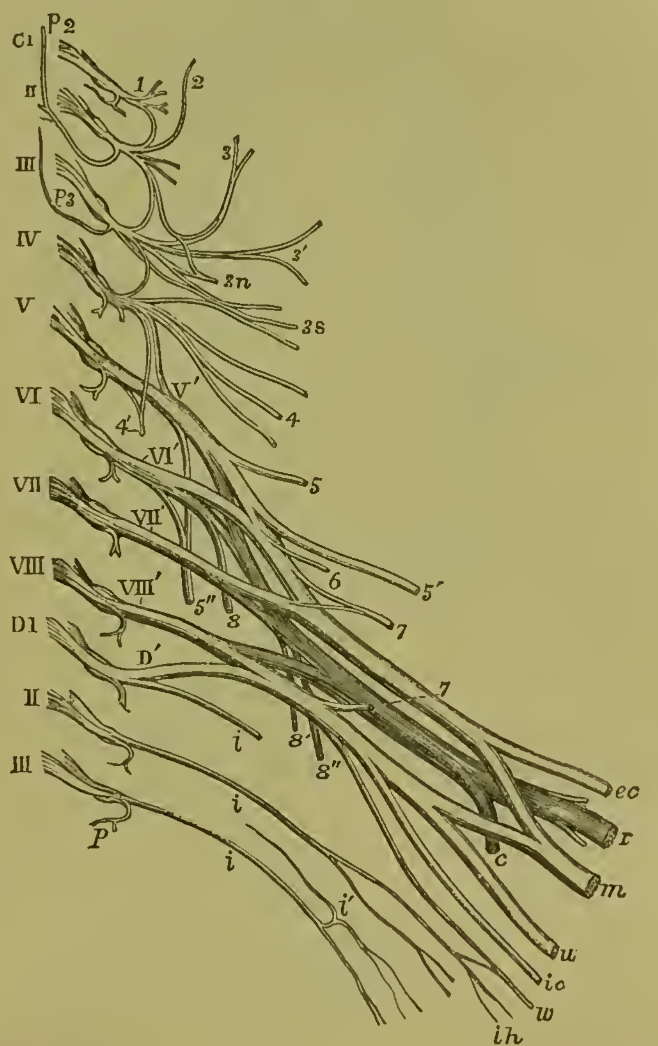


Fig. 423. — Diagrammatic Outline of the first parts of the Cervical and Upper Dorsal Nerves, showing the Cervical and Brachial Plexuses. $\frac{1}{3}$

The nerves are separated from the spinal cord at their origin and are supposed to be viewed from before. C1, is placed opposite the roots of the first cervical or suboccipital nerve, and the roman numbers in succession from II, to VIII, opposite the roots of the corresponding cervical nerves; D1, is placed opposite to the roots of the first dorsal nerve, and II, and III, opposite the second and third nerves; the origin of the posterior primary branch is shown in all the nerves; of these *p* 2, indicates the great occipital from the second, and *p* 3, the smallest occipital nerve from the third. In connection with the cervical plexus the following indications are given; 1, anterior primary branch of the first cervical nerve and loop of union with the second nerve; 2, lesser occipital nerve proceeding in this case from the second cervical nerve, more frequently from the second and third; 3, great auricular nerve from the second and third; 3′, superficial cervical nerve from the third; 3*n*, communicating branches to the descendens noni from the second and third; 3*s*, communicating to the spinal-accessory from the second, third, and fourth; 4, supraclavicular and supraacromial descending nerves: the loops or arches of communication between the four upper cervical nerves, and between the fourth and fifth are shown; 4′, the phrenic nerve springing from the fourth and fifth nerves. In connection with the nerves of the brachial plexus and the remaining nerves the following indications are given—V′, to VIII′, and D′, the five roots of the brachial plexus; 5, the rhomboid nerve; 5′, suprascapular; 5″, posterior thoracic; 6, nerve to the subclavius muscle; 7, 7, inner and outer anterior thoracic nerves; 8, 8′, 8″, upper and lower subscapular nerves. In the larger nerves proceeding to the shoulder and arm from the plexus, those of the anterior division are represented of a lighter shade, those belonging to the posterior division darker; *cc*, external cutaneous or musculo-cutaneous; *m*, median; *u*, ulnar, *ic*, internal cutaneous; *w*, nerve of Wrisberg; *r*, musculo-spiral; *c*, circumflex; *i*, intercostal nerves; *i′*, lateral branch of the same; *ih*, intercosto-humeral nerves.

I. Superficial Ascending Branches.

SUPERFICIAL CERVICAL NERVE.

This nerve takes origin from the second and third cervical nerves, turns forward over the sterno-mastoid about the middle, and, after perforating the cervical fascia, divides beneath the platysma myoides into two branches, which are distributed to the anterior and lateral parts of the neck.

a. The *upper branch* gives an ascending twig which accompanies the external jugular vein, and communicates freely with the facial nerve (cervico-facial division); it is then transmitted through the platysma to the surface, supplying that muscle, and ramifies in the integument of the upper half of the neck on the fore part, filaments reaching as high as the lower maxilla.

b. The *lower branch* likewise pierces the platysma, and is distributed below the preceding, its filaments extending in front as low as the sternum.

The superficial cervical nerve may arise from the plexus in the form of two or more distinct branches. Thus Valentin describes three superficial cervical nerves, which he names superior, middle, and inferior. ("Sömmerring v. Bau," &c.)

While the superficial cervical nerve ramifies over the platysma myoides, the facial nerve is beneath the muscle. According to Valentin many anastomotic arches are formed on the side of the neck between those two nerves, as well as between the branches of the former, one with another.

GREAT AURICULAR NERVE.

This nerve winds round the outer border of the sterno-mastoid, and is directed obliquely upwards beneath the platysma myoides, between the muscle and the deep fascia of the neck, to the lobe of the ear. Here the nerve gives a few small branches to the face, and ends in the auricular and mastoid branches.

a. The *auricular branches* are directed to the back of the external ear, on which they ramify, and are connected with twigs derived from the facial nerve. One of these branches reaches the outer surface of the ear by a fissure between the antihelix and the concha. A few filaments are supplied likewise to the outer part of the lobule.

b. The *mastoid branch* is united to the posterior auricular branch of the facial nerve, and ascends over the mastoid process to the integument behind the ear.

c. The *facial* branches of the great auricular nerve, which extend to the integuments of the face, are distributed over the parotid gland. Some slender filaments penetrate deeply through the substance of the gland, and communicate with the facial nerve.

SMALL OCCIPITAL NERVE.

The smaller occipital nerve varies in size, and is sometimes double. It springs from the second cervical nerve, and is directed almost vertically to the head along the posterior border of the sterno-mastoid muscle. Having perforated the deep fascia near the cranium, the small occipital nerve is continued upwards between the ear and the great occipital nerve, and ends in cutaneous filaments which extend upwards in the scalp; it communicates with branches from the larger occipital nerve, as well as with the posterior auricular branch of the facial. It appears to supply sometimes the occipito-frontalis muscle.

The *auricular branch* (ram. auricularis superior posterior) is distributed to the upper part of the ear on the posterior aspect, and to the elevator muscle of the auricle. This auricular branch is an offset from the great occipital nerve, when the small occipital is of less size than usual.

II. Superficial Descending Branches.

SUPRACLAVICULAR NERVES.

The descending series of the superficial nerves are thus named. There

Fig. 424.

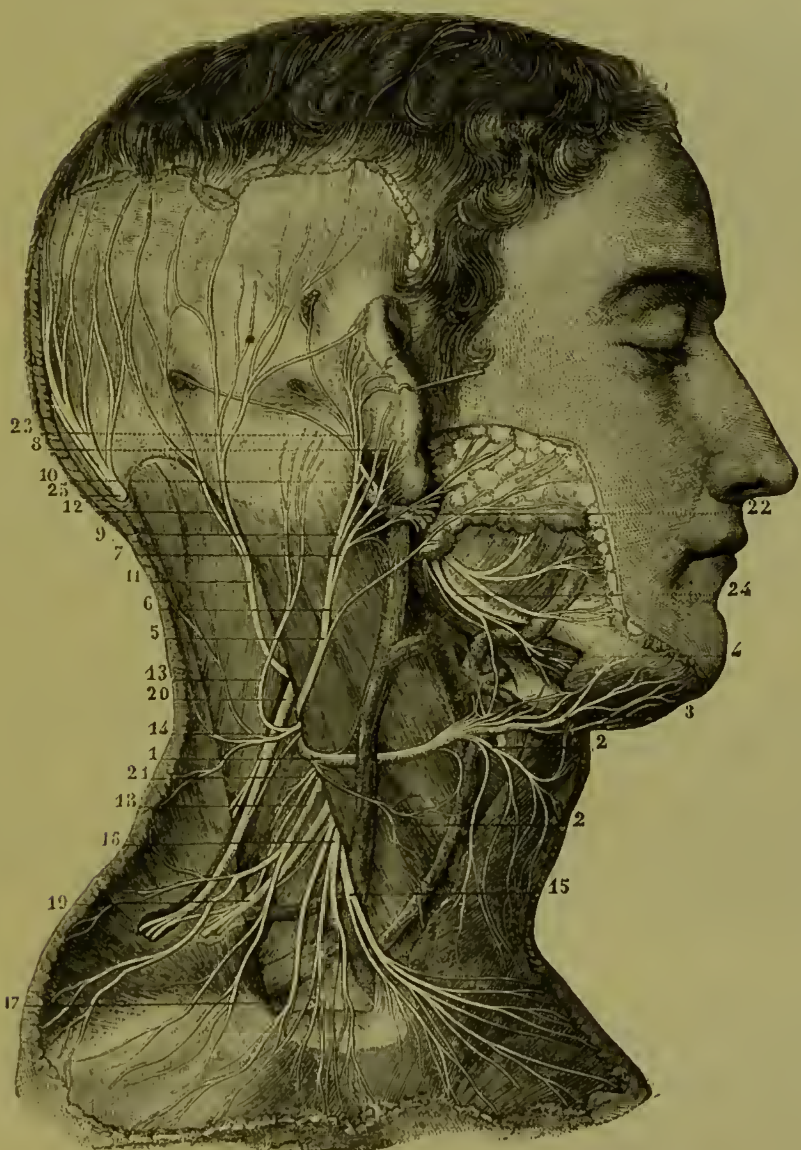


Fig. 424.—View of the Superficial Distribution of the Nerves proceeding from the Cervical Plexus (from Sappey after Hirschfeld and Leveillé). $\frac{1}{3}$

1, superficial cervical nerve ; 2, 2, descending branches of the same ; 3, ascending branches ; 4, twigs uniting with the facial ; 5, great auricular nerve ; 6, its parotid branch ; 7, its external auricular branch ; 8, twig of the same which pierces the auricle to pass to its outer surface ; 9, branch to the deep surface of the pinna ; 10, its union with the posterior auricular of the facial nerve ; 11, small occipital nerve; 12, its branch which unites with the great occipital nerve ; 13, a mastoid branch or second small occipital ; 14, twigs from this to the back of the neck ; 15, 16, supraclavicular nerves ; 17, 18, supraacromial nerves ; 19, branch of the cervical nerves passing into the trapezius muscle ; 20, spinal accessory distributed to the same and receiving a uniting branch from the cervical nerves ; 21, branch to the levator scapuli ; 22, trunk of the facial nerve ; 23, its posterior auricular branch passing into the occipital and posterior and superior auricular muscles ; 24, its cervico-facial branches.

are two of these nerves, or, in some cases, a greater number. They arise from the third and fourth cervical nerves, and descend in the interval between the sterno-mastoid and the trapezius muscles. As they approach the clavicle, the nerves are augmented to three or more in number, and are recognised as internal, middle, and posterior.

a. The *internal* (sternal) branch, which is much smaller than the rest, ramifies over the inner half of the clavicle, and terminates near the sternum.

b. The *middle branch*, lying opposite the interval between the pectoral and deltoid muscles, distributes some twigs over the fore part of the deltoid, and others over the pectoral muscle. The latter join the small cutaneous branches of the intercostal nerves.

c. The *external or posterior branch* (acromial) is directed outwards over the acromion, and the clavicular attachment of the trapezius muscle, and ends in the integument of the outer and back part of the shoulder.

III. Deep Branches : Inner Series.

CONNECTING BRANCHES.

The cervical plexus is connected near the base of the skull with the trunks of the pneumo-gastric, hypoglossal, and sympathetic nerves, by means of filaments intervening between those nerves and the loop formed by the first two cervical nerves in front of the atlas (p. 637).

MUSCULAR BRANCHES.

Branches to the anterior recti muscles proceed from the cervical nerves close to the vertebræ, including the loop between the first two of these nerves.

Two branches to the ansa hypoglossi, one from the second, the other from the third cervical nerve, descend over or under the internal jugular vein, to form a loop of communication with the ramus descendens noni, and aid in the supply of the muscles below the hyoid bone (p. 626).

PHRENIC NERVE.

The diaphragmatic or phrenic nerve passes down through the lower part of the neck and the thorax to its destination.

It commences from the fourth cervical nerve, and receives usually a fasciculus from the fifth. As it descends in the neck, the nerve is inclined inwards over the anterior scalenus muscle ; and near the chest it is joined by a filament of the sympathetic, and sometimes also by another filament derived from the fifth and sixth cervical nerves.

As it enters the thorax each phrenic nerve is placed between the subclavian artery and vein, and crosses over the internal mammary artery near the root. It then takes nearly a straight direction, in front of the root of the lung on each side, and along the side of the pericardium,—between this and the mediastinal part of the pleura. Near the diaphragm it divides into branches, which separately penetrate the fibres of that muscle, and then diverging from each other, are distributed on the under surface.

The *right nerve* is placed more deeply than the left, and is at first directed along the outer side of the right innominate vein, and the descending vena cava.

The *nerve* of the *left side* is a little longer than that of the right, in consequence of the oblique position of the pericardium round which it winds, and also because of the diaphragm being lower on this than on the opposite side. This nerve crosses in front of the arch of the aorta and the pulmonary artery before reaching the pericardium.

Besides the terminal *branches* supplied to the diaphragm, each phrenic nerve gives filaments to the pleura and pericardium; and receives sometimes an offset from the union of the descendens noni with the cervical nerves. Swan notices this union as occurring only on the left side. Luschka describes twigs from the lower part of the nerve to the peritoneum, the inferior cava, and the right auricle of the heart.

One or two filaments of the nerve of the right side join in a small ganglion with branches to the diaphragm which are derived from the solar plexus of the sympathetic; and from the ganglion twigs are given to the suprarenal capsule, the hepatic plexus, and the lower vena cava. On the left side there is a junction between the phrenic and the sympathetic nerves near the œsophageal and aortic openings in the diaphragm, but without the appearance of a ganglion.

IV. Deep Branches: External Series.

Muscular branches.—The sterno-mastoid receives a branch from the second cervical nerve. Two branches proceed from the third nerve to the levator anguli scapulæ; and from the third and fourth cervical nerves, as they leave the spinal canal, branches are given to the middle scalenus muscle. Further, the trapezius has branches prolonged to it; and thus, like the sterno-mastoid, this muscle receives nerves from both the spinal accessory and the cervical plexus.

Connection with the spinal accessory nerve.—In the substance of the sterno-mastoid muscle, this nerve is connected with the branches of the cervical plexus furnished to that muscle. It is also connected with the branches distributed to the trapezius—the union between the nerves being beneath the muscle, and having the appearance of a plexus; and with another branch of the cervical plexus in the interval between the two muscles.

Summary of the cervical plexus.—From the cervical plexus are distributed cutaneous nerves to the back of the head, to part of the ear and face, to the anterior half of the neck, and to the upper part of the trunk. The muscles supplied with nerves from the plexus are the sterno-mastoid, the platysma, and the lower hyoid muscles in part; the anterior recti, the levator anguli scapulæ, the trapezius, the scalenus medius, and the diaphragm. By means of its branches the plexus communicates with the pneumo-gastric, spinal accessory, hypoglossal, and sympathetic nerves.

BRACHIAL PLEXUS.

This large plexus, from which the nerves of the upper limb are supplied, is formed by the union of the anterior trunks of the four lower cervical and first dorsal nerves; and it further receives a fasciculus from the lowest of the nerves (fourth), which goes to form the cervical plexus. The plexus extends from the lower part of the neck to the axillary space, and terminates opposite the coracoid process of the scapula in large nerves for the supply of the limb.

The manner in which the nerves are disposed in the plexus is liable to some variation, but the following may be regarded as the arrangement most frequently met with. The fifth and sixth cervical are joined at the outer border of the scalenus, and a little farther out receive the seventh nerve,

—the three nerves giving rise to one large upper cord. The eighth cervical and first dorsal nerves are united in another lower cord whilst they are

Fig. 425.

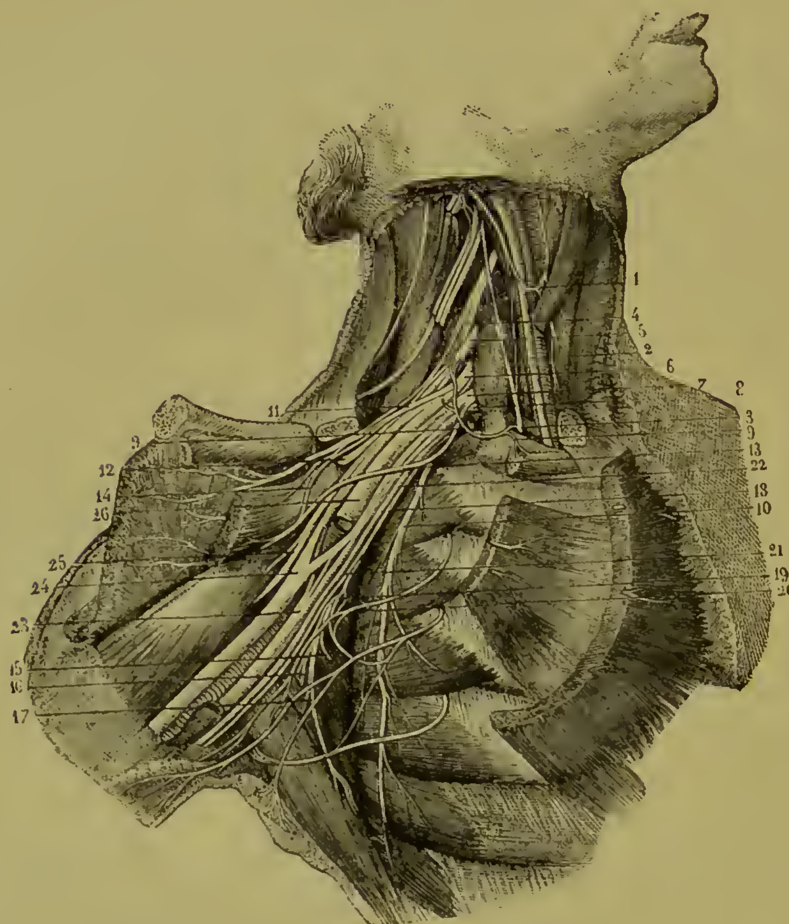


Fig. 425.—Deep Dissection of the Axilla, showing the Brachial Plexus and neighbouring Nerves (from Sappey after Hirschfeld and Leveillé). ¼

The clavicle has been sawn through near its sternal end, and is turned aside with the muscles attached to it; the subclavius, and the greater and lesser pectoral muscles have been removed from the front of the axilla. 1, loop of uniou between the descendens noni and a branch of the cervical plexus; 2, pneumo-gastric; 3, phrenic passing down to the iuner side of the scalenus anticus muscle; 4, anterior primary division of the fifth cervical nerve; 5, the same of the sixth; 6, 7, the same of the seventh and eighth cervical nerves; 8, the same of the first dorsal nerve; 9, 9, branch from the plexus to the subclavius muscle, communicating with the phrenic nerve; 10, posterior thoracic nerve distributed to the serratus magnus; 11, upper anterior thoracic uerve passing into the great pectoral muscle; 13, lower anterior thoracic distributed to the lesser pectoral; 14, twig of communication between these two nerves; 12, suprascapular nerve passing through the suprascapular notch; 15, lower of the two subscapular nerves; 16, nerve of the teres major; 17, long subscapular, or nerve of the latissimus dorsi; 18, accessory of the iuternal cutaneous nerve; 19, union of the accessory cutaneous with the second and third intercostal nerves; 20, lateral brauch of the second intercostal; 21, secoud internal cutaneous or nerve of Wrisberg; 22, internal cutaneous nerve; 23, the ulnar nerve to the inside of the axillary artery, passing behind the vein, and having, in this case, a union with the upper divisiou of the plexus; 24, the median nerve immediately below the place where its two roots embrace the artery, which is divided above this place; 25, the musculo-cutaneous nerve passing into the coraco-brachialis muscle; 26, the musculo-spiral nerve passing behind the divided brachial artery.

between the scaleni muscles. The two cords thus formed lie side by side in the fore part of the plexus, and external to the first part of the axillary vessels. At the same place, or lower down, a third, intermediate, or posterior cord is produced by the union of fasciculi from each of the other two cords, or separately from the nerves forming them. The three cords of which the plexus now consists, are placed, one on the outer side of the axillary artery, one on the inner side, and one behind that vessel, and are continued into the principal nerves for the arm.

The two fasciculi which unite to form the intermediate of the three trunks are generally separated at a higher level than the formation of the two other trunks, but they are also frequently given off as low as the clavicle, or even farther down ; this gives rise to some varieties, more apparent than real. The seventh nerve also may give a branch to the cord below it.

The branches proceeding from the plexus are numerous, and may be conveniently divided into two classes—viz., those that arise above the clavicle, and those that take origin below the bone.

BRANCHES ABOVE THE CLAVICLE.

Above the clavicle there arise from the trunks of the brachial plexus, the posterior thoracic and suprascapular nerves, a nerve for the rhomboid muscles, another for the subclavius, irregular branches for the scaleni and longus colli, and a branch to join the phrenic nerve.

The branches for *the scaleni and longus colli muscles* spring in an irregular manner from the lower cervical nerves close to their place of emergence from the vertebral foramina.

The branch for *the rhomboid muscles* arises from the fifth nerve, and is directed backwards to the base of the scapula through the fibres of the middle scalenus, and beneath the levator anguli scapulæ. It is distributed to the deep surface of the rhomboid muscles, and gives sometimes a branch to the levator scapulæ.

Fig. 426.

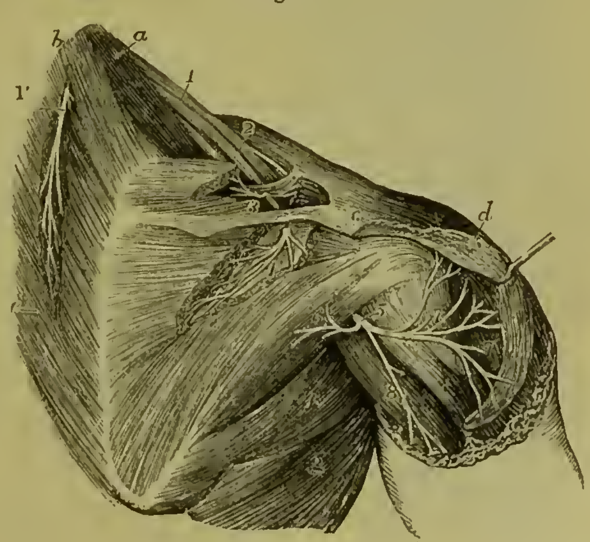


Fig. 426.—Distribution of the Suprascapular and Circumflex Nerves (from Hirschfeld and Leveillé). ½

a, the scalenus medius and posticus muscles ; *b*, levator anguli scapulæ ; *c*, acromion ; *d*, deltoid muscle, of which the back part has been detached from the scapula and in part removed ; *e*, rhomboid muscle ; *f*, teres major ; *g*, latissimus dorsi ; 1, the brachial plexus of nerves as seen from behind ; 1′, the nerve of the levator scapulæ and rhomboid muscles ; 2, placed on the clavicle, marks the suprascapular nerve ; 3, its branch to the supraspinatus muscle ; 4, branch to the infraspinatus ; 5, placed on the back of the humerus below the insertion of the teres minor, marks the circumflex nerve passing out of the quadrangular interval ; 6, its branch to the teres minor muscle ; 7, branches to the deep surface of the deltoid ; 8, cutaneous branch to the back of the shoulder.

The nerve *of the subclavius muscle*, of small size, arises from the front of the cord which results from the union of the fifth and sixth cervical nerves. It is directed over the outer part of the subclavian artery to the deep surface of the subclavius muscle. This small nerve is commonly connected with the phrenic nerve in the neck or in the chest, by means of a slender filament.

Branch *to join the phrenic nerve.*—This small and short branch is an offset from the fifth cervical nerve; it joins the phrenic nerve on the anterior scalenus muscle.

POSTERIOR THORACIC NERVE.

The posterior thoracic nerve (nerve of the serratus magnus, external respiratory of Bell) is formed in the substance of the middle scalenus muscle by two roots, one from the fifth and another from the sixth nerve, and reaches the surface of the scalenus lower than the nerve of the rhomboid muscles, with which it is often connected. It descends behind the brachial plexus on the outer surface of the serratus magnus, nearly to the lower border of that muscle, supplying it with numerous branches.

SUPRASCAPULAR NERVE.

The suprascapular nerve arises from the back of the cord formed by the union of the fifth and sixth nerves, and bends beneath the trapezius to the upper border of the scapula, where it passes between the muscles and the bone. Entering the supraspinous fossa of the scapula, through the suprascapular notch (beneath the ligament which crosses the notch), the suprascapular nerve supplies two branches to the supraspinatus, one near tho upper, the other near the lower part of the muscle; and it then descends through the great scapular notch into the lower fossa, where it ends in the infraspinatus muscle.

In the upper fossa of the scapula, a slender *articular filament* is given to the shoulder-joint, and in the lower fossa other twigs of the nerve enter the same joint and the substance of the scapula.

BRANCHES BELOW THE CLAVICLE.

Origin of nerves from the plexus.—The several nerves now to be described are derived from the three great cords of the plexus in the following order.

From the upper or outer cord,—the external of the two anterior thoracic nerves, the musculo-cutaneous, and the outer root of the median.

From the lower or inner cord,—the inner of the two anterior thoracic, the nerve of Wrisberg, the internal cutaneous, the ulnar, and the inner root of the median.

From the posterior cord,—the subscapular nerves, the circumflex, and the musculo-spiral.

The nerves traced to the spinal nerves.—If the fasciculi of which the principal nerves are composed be followed through the plexus, they may be traced to those of the spinal nerves which in the subjoined table are named along with each trunk. The higher numbers refer to the cervical nerves, the unit to the dorsal nerve:—

Subscapular from	5.6.7.8.	Ulnar	8.1. or 7.8.1.
Circumflex	5.6.7.8.	Internal cutaneous	8.1.
Musculo-spiral	5.6.7.8.	Small internal cutaneous	8.1.
External cutaneous	5.6.7.	Anterior thoracic	outer 5.6.7.
Median	5.6.7.8.1.		inner 8.1.

The outline in Fig. 423, taken from a dissection, represents one of the most common arrangements.

Some differences will be found in the statements of anatomists who have investigated the subject—for instance, Scarpa ("Annotationes Anatom.") and Kronenberg ("Plex. nervor. Structura et Virtutes")—with respect to the nerves to which the branches are assigned. This difference is mainly owing to the variation which actually exists in different cases.

ANTERIOR THORACIC NERVES.

The anterior thoracic nerves, two in number, supply the pectoral muscles.

The *external*, or more superficial branch, arising from the outer cord, crosses inwards over the axillary artery, and terminates in the great pectoral muscle.

The *internal*, or deeper branch, springing from the inner cord, comes forwards between the axillary artery and vein to the small pectoral muscle, and is joined by a branch from the external. This nerve presents a plexiform division beneath the small pectoral muscle, and supplies branches to it and the larger pectoral muscle. The two nerves are connected by a filament which forms a loop over the artery at the inner side.

SUBSCAPULAR NERVES.

These nerves, three in number, take origin from the posterior cord of the plexus.

The *upper* nerve, the smallest of the subscapular nerves, penetrates the upper part of the subscapular muscle. The *lower* nerve gives a branch to the subscapularis at its axillary border, and ends in the teres major muscle. There is sometimes a distinct nerve for the last-named muscle.

The *long subscapular* nerve, the largest of the three, runs along the lower border of the subscapular muscle to the latissimus dorsi, to which it is distributed.

Fig. 427.

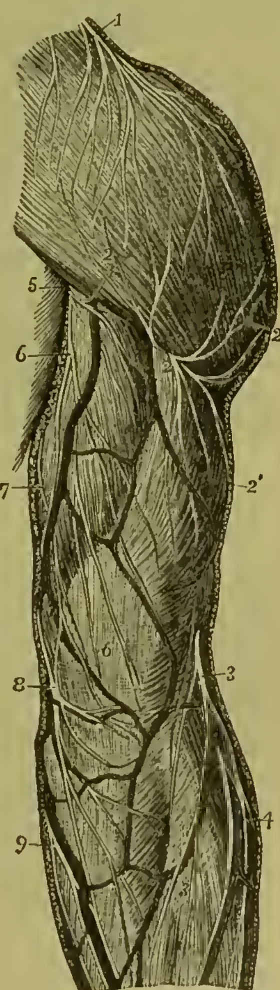


Fig. 427.—Distribution of the Posterior Cutaneous Nerves of the Shoulder and Arm (from Hirschfeld and Leveillé). $\frac{1}{5}$

1, supra-acromial branches of the cervical nerves descending on the deltoid muscle; 2, ascending or reflected, and 2′, descending cutaneous branches of the circumflex nerve; 3, inferior external cutaneous of the musculo-spiral nerve; 4, external and posterior cutaneous branches of the musculo-cutaneous nerve to the forearm; 5, internal cutaneous of the musculo-spiral; 6, intercosto-humeral branches; 7, twigs of the nerve of Wrisberg; 8, upper posterior branch of the internal cutaneous nerve; 9, lower branch of the same.

CIRCUMFLEX NERVE.

The circumflex or axillary nerve gives both muscular and cutaneous nerves to the shoulder. Springing from the posterior cord, this nerve is at first placed behind the axillary artery, but at the lower border of the subscapular muscle it is inclined backwards with the posterior circumflex artery, in the space between the scapula and teres

major muscle above the long head of the triceps, and separates into an upper and a lower branch, which are distributed to the deltoid and teres minor muscles, the integument of the shoulder, and the shoulder joint.

a. The *upper portion* winds round the upper part of the humerus, extending to the anterior border of the deltoid muscle, to which it is distributed. One or two *cutaneous filaments*, penetrating between the muscular fibres, are bent downwards, and supply the integument over the lower part of the muscle.

b. The *lower branch* supplies offsets to the back part of the deltoid, and furnishes the nerve to the teres minor, which is remarkable in presenting a gangliform enlargement. It then turns round the posterior border of the deltoid below the middle, and ramifies in the integument over the lower two-thirds of that muscle, one branch extending to the integument over the long head of the triceps muscle.

c. An *articular filament* for the shoulder-joint arises near the commencement of the nerve, and enters the capsular ligament below the subscapular muscle.

INTERNAL CUTANEOUS NERVE.

At its origin from the inner cord of the brachial plexus, this nerve is placed on the inner side of the axillary artery. It becomes cutaneous about the middle of the arm, and after perforating the fascia, or, in some cases, before doing so, is divided into two parts; one destined for the anterior, the other for the posterior surface of the forearm.

a. The *anterior branch* crosses at the bend of the elbow behind (in some cases over) the median basilic vein, and distributes filaments in front of the forearm, as far as the wrist; one of these is, in some instances, joined with a cutaneous branch of the ulnar nerve.

b. The *posterior branch* inclines obliquely downwards at the inner side of the basilic vein, and winding to the back of the forearm, over the prominence of the internal condyle of the humerus, extends somewhat below the middle of the forearm. Above the elbow this branch is connected with the smaller internal cutaneous nerve (nerve of Wrisberg), and afterwards communicates with the outer portion of the internal cutaneous, and, according to Swan, with the dorsal branch of the ulnar nerve.

c. A branch to the *integument of the arm* pierces the fascia near the axilla, and reaches to, or nearly to the elbow, distributing filaments outwards over the biceps muscle. This branch is often connected with the intercosto-humeral nerve.

SMALL INTERNAL CUTANEOUS NERVE.

The smaller internal cutaneous nerve, or nerve of Wrisberg, destined for the supply of the integument of the lower half of the upper arm on the inner and posterior aspect, commonly arises from the inner cord of the brachial plexus in union with the larger internal cutaneous and ulnar nerves. In the axilla it lies close to the axillary vein, but it soon appears on the inner side of that vessel, and communicates with the intercosto-humeral nerve. It then descends along the inner side of the brachial vessels to about the middle of the arm, where it pierces the fascia, and its filaments are thence continued to the interval between the internal condyle of the humerus and the olecranon.

Branches.—In the lower third of the arm, branches of this small nerve are directed almost horizontally to the integument on the posterior aspect; and the nerve ends at the elbow by dividing into several filaments, some of which are directed forwards over the inner condyle of the humerus, while others are prolonged downwards behind the olecranon.

Connection with the intercosto-humeral nerve.—This connection presents much variety in different cases:—in some, there are two or more intercommunications, forming a kind of plexus on the posterior boundary of the axillary space; in others, the

intercosto-humeral nerve is of larger size than usual, and takes the place of the nerve of Wrisberg, only receiving in the axilla a small filament from the brachial plexus,

Fig. 428.

Fig. 429.

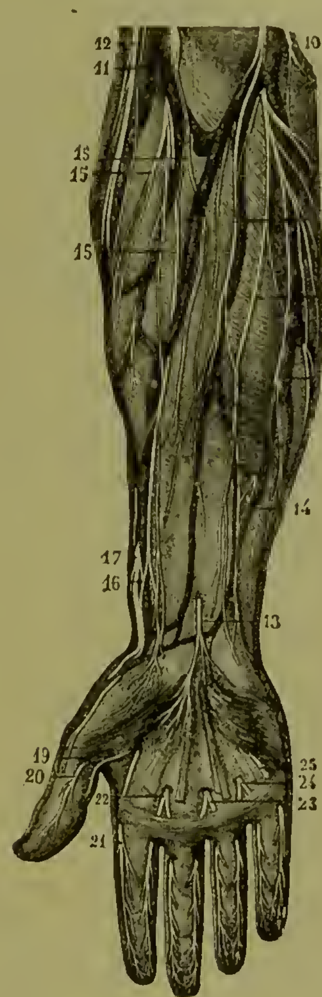


Fig. 428.—Anterior Cutaneous Nerves of the Shoulder and Arm (from Sappey after Hirschfeld and Leveillé). $\frac{1}{5}$

1, 1, supraclavicular and supraacromial nerves from the cervical plexus ; 2, 2, 2, cutaneous branches of the circumflex nerve ; 3, 4, upper branches of the internal cutaneous nerve ; 5, superior external cutaneous branch of the musculo-spiral ; 6, internal cutaneous nerve piercing the deep fascia ; 7, posterior branch ; 8, communicating twig with one of the anterior branches ; 9, 10, anterior branches of this nerve, some turning round the median basilic and ulnar veins ; 11, musculo-cutaneous nerve descending over the median cephalic vein ; 12, inferior cutaneous branch of the musculo-spiral nerve.

Fig. 429.—Anterior Cutaneous Nerves of the Forearm and Hand (from Sappey after Hirschfeld and Leveillé). $\frac{1}{5}$

9, 10, 13, distribution of the anterior branches of the internal cutaneous nerve ; 14, union of one of these with a twig of the ulnar nerve ; 12, inferior cutaneous branch of the musculo-spiral nerve ; 11, 15, distribution of the external cutaneous nerve ; 16, union of one of its branches with 17, the terminal branch of the radial nerve ; 18, palmar cutaneous branch of the median nerve ; 19, 20, internal and external collateral branches to the thumb from the median nerve ; 21, external collateral to the index finger ; 22, 23, collateral branches to the index, middle and fourth fingers ; 24, 25, collateral branches from the ulnar nerve to the fourth and fifth fingers ; the network of communicating twigs formed by the terminal branches of these cutaneous nerves is represented at the extremities of the fingers.

and this small communicating filament represents in such cases the nerve of Wrisberg.

MUSCULO-CUTANEOUS NERVE.

The musculo-cutaneous or external cutaneous nerve (perforans Casserii) is deeply placed between the muscles as far as the elbow, and below that point is immediately under the integument. Arising from the brachial plexus opposite the small pectoral muscle, it perforates the coraco-brachialis muscle, and, passing obliquely across the arm between the biceps and brachialis anticus muscles, reaches the outer side of the biceps a little above the elbow. Here it perforates the fascia, and nearly opposite the elbow-joint it passes behind the median-cephalic vein, and, inclining outwards, divides into two branches which supply the integument on the outer side of the forearm, one on the anterior, the other on the posterior aspect.

A. *Branches in the arm* :—

a. A branch to the coraco-brachialis and short head of the biceps is given off before the nerve pierces the former muscle; and other filaments are furnished to the coraco-brachialis, while the nerve lies among its fibres.

b. Branches to the biceps and brachialis anticus are given off while the nerve is between those muscles.

c. Small filaments are given to the humerus and elbow joint.

B. *Branches in the forearm* :—

a. The *anterior branch* descends near the radial border of the forearm. It is placed in front of the radial artery near the wrist, and distributes some filaments over the ball of the thumb. Piercing the fascia, it accompanies the artery to the back part of the carpus. This part of the nerve is connected at the wrist with a branch of the radial nerve.

b. The *posterior branch* is directed outwards to the back of the forearm, and ramifies in the integument of the lower third, extending as far as the wrist. It communicates with a branch of the radial nerve, and with the external cutaneous branch of the musculo-spiral nerve.

Summary.—The musculo-cutaneous nerve supplies the coraco-brachialis, biceps and brachialis anticus muscles, and the integument on the outer side of the forearm. Communications are established between it and the radial and the external cutaneous branch of the musculo-spiral.

Varieties.—In some cases it does not perforate the coraco-brachialis muscle. It is frequently found to communicate by a cross branch with or to be an offset of the median nerve ; and in the latter case, the coraco-brachialis muscle receives a separate branch from the brachial plexus, which may be explained thus,—that the main part of the musculo-cutaneous nerve, instead of piercing the coraco-brachialis muscle, remains adherent to the outer root and trunk of the median.

ULNAR NERVE.

The ulnar nerve, the largest branch of the inner cord of the brachial plexus, descends on the inner side of the artery of the limb as far as the middle of the arm, then turns backwards through the internal intermuscular septum with the inferior profunda artery, to reach the interval between the olecranon and the inner condyle of the humerus. From the axilla to this place it is covered only by the fascia, and it may be felt through the integument a little above the elbow. It here passes between the two heads of the flexor carpi ulnaris, and it remains concealed by that muscle as far as the middle of the forearm ; it thence extends in a straight course along the outer margin of the muscle, between it and the ulnar artery, to the outer

side of the pisiform bone. Above the wrist it gives off a large dorsal branch to the hand, and continuing onwards it enters the palm on the surface of the annular ligament, and divides into muscular and cutaneous branches.

The ulnar nerve gives off no branches in the upper arm.

A. *Branches in the forearm :—*

a. Articular filaments are given to the elbow joint as the nerve passes behind it. Some filaments are also given to the wrist joint.

b. Muscular branches.—One branch enters the upper part of the flexor carpi ulnaris, and another supplies the two inner divisions of the deep flexor of the fingers.*

c. Cutaneous branches to the forearm.—These two small nerves arise about the middle of the forearm by a common trunk. One pierces the fascia, and turning downwards, joins a branch of the internal cutaneous nerve. This branch is often absent. The second, a *palmar branch,* lies on the ulnar artery, which it accompanies to the hand. This little nerve gives filaments around the vessel, and ramifies in the integument of the hand, joining in some cases with other cutaneous offsets of the ulnar or median nerve.

d. Dorsal branch to the hand.—This large offset, leaving the trunk of the ulnar nerve two or three inches above the wrist, winds backwards beneath the flexor carpi ulnaris, and divides into branches; one of these ramifies on the inner side of the little finger, another divides to supply the contiguous sides of that finger and the ring finger, while a third joins on the back of the metacarpus with the branch of the radial nerve which supplies the contiguous sides of the ring and middle finger. The several posterior digital nerves, now described, are united with twigs directed backwards from the anterior digital nerves of the same fingers.

B. *Palmar branches :—*

a. The *deep branch* separates from the trunk beyond the annular ligament, and dipping down through the muscles of the little finger in company with the deep branch of the ulnar artery, it follows the course of the deep palmar arch across the hand. It supplies the short muscles of the little finger as it pierces them; and as it lies across the metacarpal bones, it distributes two branches to each interosseous space—one for the palmar, the other for the dorsal interosseous muscle, and supplies filaments to the two innermost lumbricales muscles. Opposite the space between the thumb and the index finger the nerve ends in branches to the adductor pollicis, and the inner head of the flexor brevis pollicis.

b. The remaining part of the nerve supplies a branch to the palmaris brevis muscle and small twigs to the integument, and divides into two digital branches.

Digital nerves.—One of these belongs to the ulnar side of the little finger. The other is connected in the palm of the hand with a digital branch of the median nerve, and at the cleft between the little and ring fingers, divides into the collateral nerves for these fingers. The terminal disposition of the digital branches on the fingers is the same as that of the median nerve, to be presently described.

Summary.—The ulnar nerve gives cutaneous filaments to the lower part of the forearm (to a small extent), and to the hand on its palmar and dorsal aspects. It supplies the following muscles, viz., the ulnar flexor of the carpus, the deep flexor of the fingers (its inner half), the short muscles of the little finger with the palmaris brevis, the interosseous muscles of the hand, the two internal lumbricales, the adductor pollicis and the inner half of the flexor brevis pollicis. Lastly, it contributes to the nervous supply of the elbow and wrist joints.

MEDIAN NERVE.

The median nerve arises by two roots, one from the outer, the other from the inner cord of the brachial plexus. Commencing by the union of these

* A case has been recorded in which the ulnar nerve supplied also two branches to the flexor sublimis digitorum (Turner, "Nat. Hist. Review," 1864).

Fig. 430.

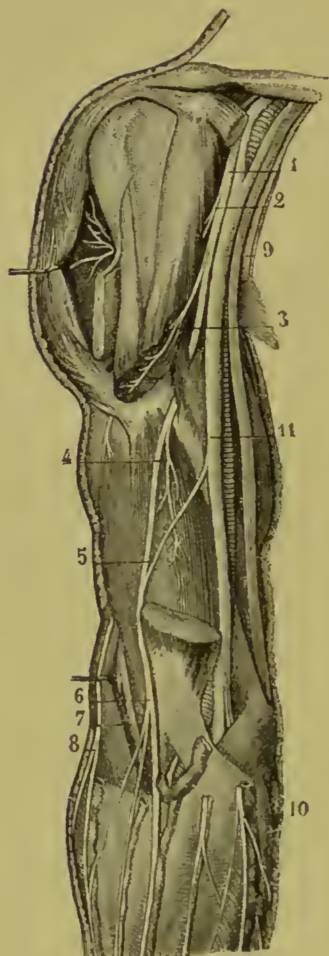


Fig. 431.

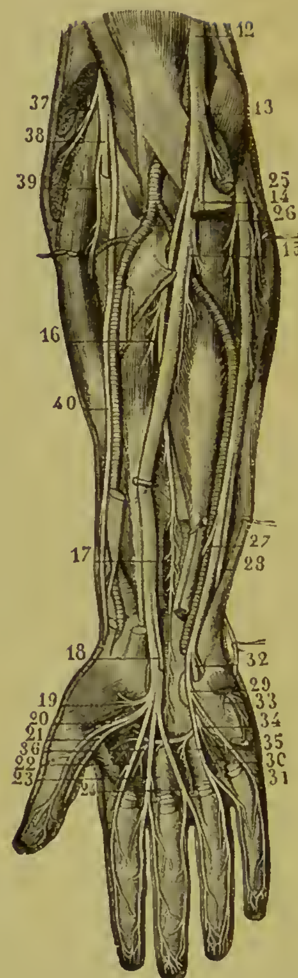


Fig. 430.—Deep View of the Anterior Nerves of the Shoulder and Arm (from Sappey after Hirschfeld and Leveillé). $\frac{1}{5}$

1, musculo-cutaneous nerve ; 2, its twig to the coraco-brachialis muscle ; 3, its branch to the biceps ; 4, its branch to the brachialis anticus ; 5, twig of union with the median nerve (a variety) ; 6, continuation of the nerve in its cutaneous distribution ; 7, musculo-spiral nerve in the interval between the brachialis anticus and supinator longus ; 8, inferior external cutaneous branch of the musculo-spiral ; 9, the internal cutaneous and small internal cutaneous nerves divided ; 10, anterior branch of the internal cutaneous ; 11, median nerve ; to the inside the ulnar nerve is crossed by the line from 11.

Fig. 431.—Deep View of the Anterior Nerves of the Forearm and Hand (from Sappey after Hirschfeld and Leveillé). $\frac{1}{5}$

12, the median nerve ; 13, its branches to the pronator teres ; 14, branch to the superficial flexor muscles, which have been removed ; 15, branch to the flexor digitorum profundus ; 16, branch to the flexor longus pollicis ; 17, anterior interosseous branch ; 18, cutaneous palmar branch cut short ; 19, branches to the short muscles of the thumb ; 20, 21, collateral branches to the thumb ; 22, 23, 24, collateral branches to the second, third, and fourth fingers ; 25, branch given by the ulnar nerve to the flexor carpi ulnaris ; 26, branch to the flexor digitorum profundus ; 27, cutaneous communicating twig ; 28, dorsal branch of the ulnar ; 29, superficial palmar branch ; 30, 31, collateral branches to the fourth and fifth fingers ; 32, deep palmar branch ; 33, its branch to the short muscles of the little finger ; 34, 35, 36, twigs given by the deep branch of the ulnar to the third and fourth lumbricales, all the interossei, and the adductor pollicis.

roots in front or on the outer side of the axillary artery, the nerve descends in contact with the brachial artery, gradually passing inwards over it, and near the elbow is at the inner side of the vessel. Crossing the bend of the arm it passes beneath the pronator radii teres, separated by the deep slip of that muscle from the ulnar artery, and continues straight down the front of the forearm, between the flexor sublimis digitorum and flexor profundus. Arrived near the wrist it lies beneath the fascia, between the tendons of the flexor sublimis and that of the flexor carpi radialis. It then enters the palm behind the annular ligament, and rests on the flexor tendons. Somewhat enlarged, and of a slightly reddish colour, it here separates into two parts of nearly equal size. One of these (the external) supplies some of the short muscles of the thumb, and gives digital branches to the thumb and the index finger; the second portion supplies the middle finger, and in part the index and ring fingers.

The median nerve gives no branch to the upper arm.

A. *Branches in the forearm*:—

In the forearm the median nerve supplies muscular branches, and, near the wrist, a single cutaneous filament. All the muscles on the front of the forearm (pronators and flexors), except the flexor carpi ulnaris and part of the deep flexor of the fingers, are supplied from this nerve.

a. The branches for the superficial muscles are separate twigs given off from the nerve below or near the elbow-joint, but the branch furnished to the pronator teres often arises above the joint.

b. Anterior interosseous nerve.—This is the longest branch of the median nerve, and it supplies the deeper muscles of the forearm. Commencing at the upper part of the forearm, beneath the superficial flexor of the fingers, it passes downwards with the anterior interosseous artery on the interosseous membrane, and between the long flexor of the thumb and the deep flexor of the fingers, to the pronator quadratus muscle, in which it ends.

c. The *cutaneous palmar branch* pierces the fascia of the forearm close to the annular ligament, and descending over that ligament, ends in the integument of the palm about the middle; being connected by a twig with the cutaneous palmar branch of the ulnar nerve. It distributes some filaments over the ball of the thumb, which communicate with twigs of the radial or the external cutaneous nerve.

B. *Branches in the hand*:—

a. Branch to muscles of the thumb.—This short nerve subdivides into branches for the abductor, the opponens, and the outer head of the flexor brevis pollicis muscle.

b. Digital nerves.—These are five in number, and belong to the thumb, and the fingers as far as the outer side of the ring finger. As they approach the clefts between the fingers, they are close to the integument in the intervals between the longitudinal divisions of the palmar fascia.

The *first* and *second* nerves lie along the sides of the thumb; and the former (the outer one) is connected with the radial nerve upon the ball of the thumb.

The *third*, destined for the radial side of the index finger, gives a muscular branch to the first or most external lumbrical muscle.

The *fourth* supplies the second lumbricalis, and divides into branches for the adjacent sides of the index and middle fingers.

The *fifth*, the most internal of the digital nerves, is connected by a crossing twig with the ulnar nerve, and divides to furnish branches to the adjacent sides of the ring and middle fingers.

Each digital nerve divides at the end of the finger into two branches, one of which supplies the ball on the fore part of the finger; the other ramifies in the pulp beneath the nail. Branches pass from each nerve forwards and backwards to the integument of the finger; and one larger than the rest

inclines backwards by the side of the first phalanx of the finger, and after joining the dorsal digital nerve, ends in the integument over the last phalanx.

Fig. 432.

Fig. 432.—Distribution of the Digital Nerves (from Hirschfeld and Leveillé). ½

1, palmar collateral nerve ; 2, its final palmar distribution ; 3, its dorsal or ungual distribution, and between these numbers the network of terminal filaments ; 4, collateral dorsal nerve; 5, uniting twigs passing between the dorsal and palmar digital nerves.

Summary.—The median nerve gives cutaneous branches to the palm, and to several fingers. It supplies the pronator muscles, the flexors of the carpus and the long flexors of the fingers (except the ulnar flexor of the carpus, and part of the deep flexor of the fingers), likewise the outer set of the short muscles of the thumb, and two lumbricales.

Some similarity will be observed between the course and distribution of the median and ulnar nerves. Neither gives any offset in the arm. Together they supply all the muscles in front of the forearm and in the hand, and together they supply the skin of the palmar surface of the hand, and impart tactile sensibility to all the fingers.

MUSCULO-SPIRAL NERVE.

The musculo-spiral nerve, the largest offset of the brachial plexus, occupies chiefly the back part of the limb, and supplies nerves to the extensor muscles, as well as to the skin.

Arising behind the axillary vessels from the posterior cord of the brachial plexus, of which it is the principal continuation and the only one prolonged into the arm, it soon turns backwards into the musculo-spiral groove, and, accompanied by the superior profunda artery, proceeds along that groove, between the humerus and the triceps muscle, to the outer side of the limb. It then pierces the external intermuscular septum, and descends in the interval between the supinator longus and the brachialis anticus muscle to the level of the outer condyle of the humerus, where it ends by dividing into the radial and posterior interosseous nerves. Of these, the radial is altogether a cutaneous nerve, and the posterior interosseous is the muscular nerve of the back of the forearm.

The branches of the musculo-spiral nerve may be classified according as they arise on the inner side of the humerus, behind that bone, or on the outer side.

A. Internal branches :—

(*a*) *Muscular branches* for the inner and middle heads of the triceps. That for the inner portion of the muscle is long and slender; it lies by the side of the ulnar nerve, and reaches as far as the lower third of the upper arm. One branch, previously noticed by authors, but more particularly described by Krause, is named by him the *ulnar collateral* branch. It arises opposite the outer border of the latissimus dorsi tendon, and descends within the sheath of the ulnar nerve, through the internal intermuscular septum, and is distributed to the short inferior fibres of the triceps (Reichert and Du Bois Reymond's Archiv. 1864).

(*b*) The *internal cutaneous* branch of the musculo-spiral nerve, commonly united in origin with the preceding, winds backwards beneath the intercosto-humeral nerve, and after supplying filaments to the skin, ends about two inches from the olecranon ;

in some instances extending as far as the olecranon. This nerve is accompanied by a small cutaneous artery.

B. Posterior branches :—

These consist of a fasciculus of *muscular branches* which supply the outer head of the triceps muscle and the anconeus. The *branch* of the *anconeus* is slender, and remarkable for its length; it descends in the substance of the triceps to reach its destination.

C. External branches :—

(*a*) The *muscular branches* supply the supinator longus, extensor carpi radialis longior, (the extensor carpi radialis brevior receiving its nerve from the posterior interosseous,) and occasionally give a small branch to the brachialis anticus.

(*b*) The *external cutaneous branches*, two in number, arise where the nerve pierces the external intermuscular septum.

The *upper branch*, the smaller of the two, is directed downwards to the fore part of the elbow, along the cephalic vein, and distributes filaments to the lower half of the upper arm on the anterior aspect. The *lower branch* extends as far as the wrist, distributing offsets to the lower half of the arm, and to the fore arm, on their posterior aspect, and is connected near the wrist with a branch of the external cutaneous nerve.

Fig. 433.

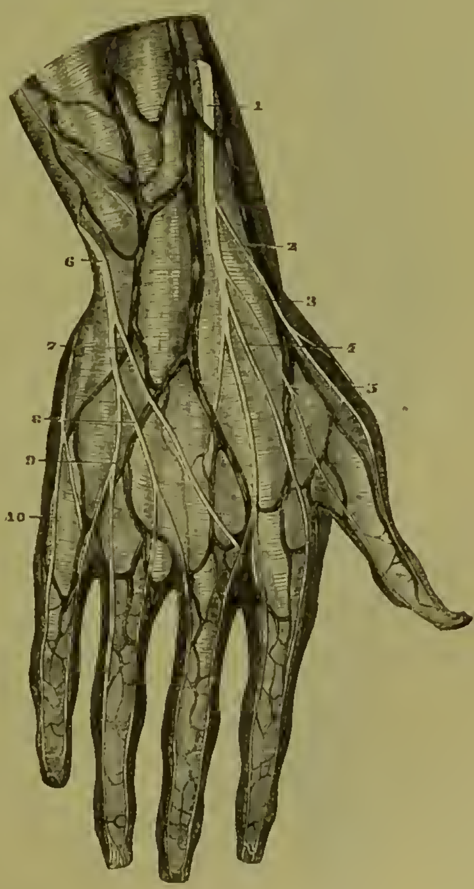


Fig. 433.—Dorsal Cutaneous Nerves of the Hand. $\frac{1}{3}$

The distribution delineated in this figure is not the most common, there being a larger than usual branch of the ulnar nerve : 1, the radial nerve descending beside the principal radial cutaneous vein ; 2, and 3, dorsal branches to the two sides of the thumb ; 4, branch to the radial side of the forefinger ; 5, branch to the forefinger and middle finger, and communicating with one from the ulnar nerve ; 6, the posterior branch of the ulnar nerve ; 7, communicating twig ; 8, collateral branch to the middle and ring fingers ; 9, collateral branch to the ring and little fingers ; 10, branch to the inner side of the hand and little finger.

RADIAL NERVE.

The radial nerve, continuing straight down from the musculo-spiral, is concealed by the long supinator muscle, and lies a little to the outer side of the radial artery. This position beneath the supinator is retained to about three inches from the lower end of the radius, where the nerve turns backwards beneath the tendon of the muscle, and becomes subcutaneous. It then separates into two branches, which ramify in the integument on the dorsal aspect of the thumb and the next two fingers in the following manner :—

(*a*) The *external branch* extends to the radial side of the thumb, and is joined by an offset of the external cutaneous nerve. It distributes filaments over the ball of the thumb.

(*b*) The *internal portion* communicates with a branch of the external cutaneous nerve on the back of the forearm, and divides into digital branches; *one* running along the ulnar side of the thumb, a *second* on the radial side of the index finger, a *third* dividing to supply the adjacent sides of the index and middle fingers, while a *fourth* joins with an offset from the dorsal branch of the ulnar, and along with it forms a branch for the supply of the contiguous sides of the middle and ring fingers. These branches communicate on the sides of the fingers with the palmar digital nerves.

Sometimes the interspace between the middle and ring fingers is entirely supplied by the radial, and at other times entirely by the ulnar nerve.

POSTERIOR INTEROSSEOUS NERVE.

This nerve, the larger of the two divisions of the musculo-spiral nerve, winds to the back of the forearm through the fibres of the supinator brevis

Fig. 434.

Fig. 434.—View of the Radial side of the Fore-arm, showing the final distribution of the Musculo-Spiral Nerve (from Hirschfeld and Leveillé). ¼

The supinator longus, and extensores carpi radiales longior and brevior have been divided, and their upper parts removed; the extensor communis digitorum is pulled backwards by a hook, and the supinator brevis has been partially dissected to show the posterior interosseous nerve passing through it.

1, placed upon the tendon of the biceps muscle, points to the musculo-cutaneous nerve; 1′, near the wrist, the lower part of this nerve and its plexus of union with the radial nerve; 2, trunk of the musculo-spiral nerve emerging from between the brachialis anticus, on which the number is placed, and the supinator longus muscles; 2′, its muscular twigs to the long supinator and long radial extensor of the carpus; 2″, the posterior interosseous nerve passing through the substance of the supinator brevis; 3, placed upon the cut lower portion of the supinator longus, the radial nerve; 4, the external collateral nerve of the thumb; 5, the common collateral of the fore-finger and thumb; 6, the common collateral of the fore-finger and middle finger; 7, the twig of union with the dorsal branch of the ulnar nerve; 8, placed upon the common extensor of the fingers, the muscular branches of the posterior interosseous nerve to the long extensor muscles; 9, upon the extensor secundi internodii pollicis, the branches to the short extensor muscles.

muscle, and is prolonged between the deep and superficial layers of the extensor muscles to the interosseous membrane, which it approaches about the middle of the forearm.

Much diminished in size by the separation of numerous branches for the muscles, the nerve lies at the lower part of the forearm beneath the extensor of the last phalanx of the thumb and the tendons of the common extensor of the fingers, and terminates on the back of the carpus in a gangliform enlargement, from which filaments are given to the adjoining ligaments and articulations.

The *branches* of the interosseous nerve enter the surrounding muscles, viz., the extensor carpi radialis brevior and supinator brevis, the superficial layer of the extensor muscles except the anconeus, and the deep layer of the same muscles :—that is to say, the nerve supplies the supinators, and the extensors of the carpus and fingers, with the exception of the supinator longus and the extensor carpi radialis longior.

Summary of the Musculo-spiral Nerve.

The trunk of the nerve distributes its branches to the extensor muscles of the elbow-joint exclusively, with the exception of a filament to the brachialis anticus, which however receives its principal nerves from another source. Before separating into its two large divisions, the nerve gives branches to two muscles of the forearm, viz., the long supinator, and the long radial extensor of the carpus. The posterior interosseous division distributes nerves to the remaining muscles on the outer and back part of the forearm, except the anconeus (previously supplied), viz., to the short supinator and the extensors.

Cutaneous nerves are distributed, from the trunk of the nerve and its radial division, to the lower part of the upper arm, to the forearm, and to the hand—on the posterior and outer aspect of each.

ANTERIOR PRIMARY DIVISIONS OF THE DORSAL NERVES.

These nerves are twelve in number, and, with the exception of the larger part of the first of them, which joins the brachial plexus, they are distributed to the walls of the thorax and abdomen. Eleven of the nerves so distributed are termed intercostal, and the twelfth is situated below the last rib. The cords connecting them with the sympathetic nerve, placed close to the vertebræ, are very short.

The anterior divisions of these nerves pass separately to their destination, without forming any plexus by the connection or interlacement of their fibres, and in this respect they differ from those of the other spinal nerves. From the intervertebral foramina they are directed transversely across the trunk, and nearly parallel one to another. The upper six nerves, with the exception of the first, are confined to the parietes of the thorax ; while the lower six nerves are continued from the intercostal spaces to the muscles and integument of the anterior wall of the abdomen.

FIRST DORSAL NERVE.

The greater part of the anterior division of this nerve ascends over the neck of the first rib and the first intercostal artery to enter into the brachial plexus. The remaining portion of the nerve is continued as the *first intercostal,* a small branch which courses along the first intercostal space, in the manner of the other intercostal nerves, but has usually no lateral cutaneous branch, and may also want the anterior cutaneous.

UPPER OR PECTORAL INTERCOSTAL NERVES.

In their course to the fore part of the chest, these nerves accompany the intercostal blood-vessels. After a short space they pass between the internal and external intercostal muscles, supplying them with twigs, and, about midway between the vertebræ and the sternum, give off the lateral cutaneous branches. The nerves, greatly diminished, are now continued forwards amid the fibres of the internal intercostal muscles as far as the costal cartilages, where they come into contact with the pleura. In approaching

Fig. 435.

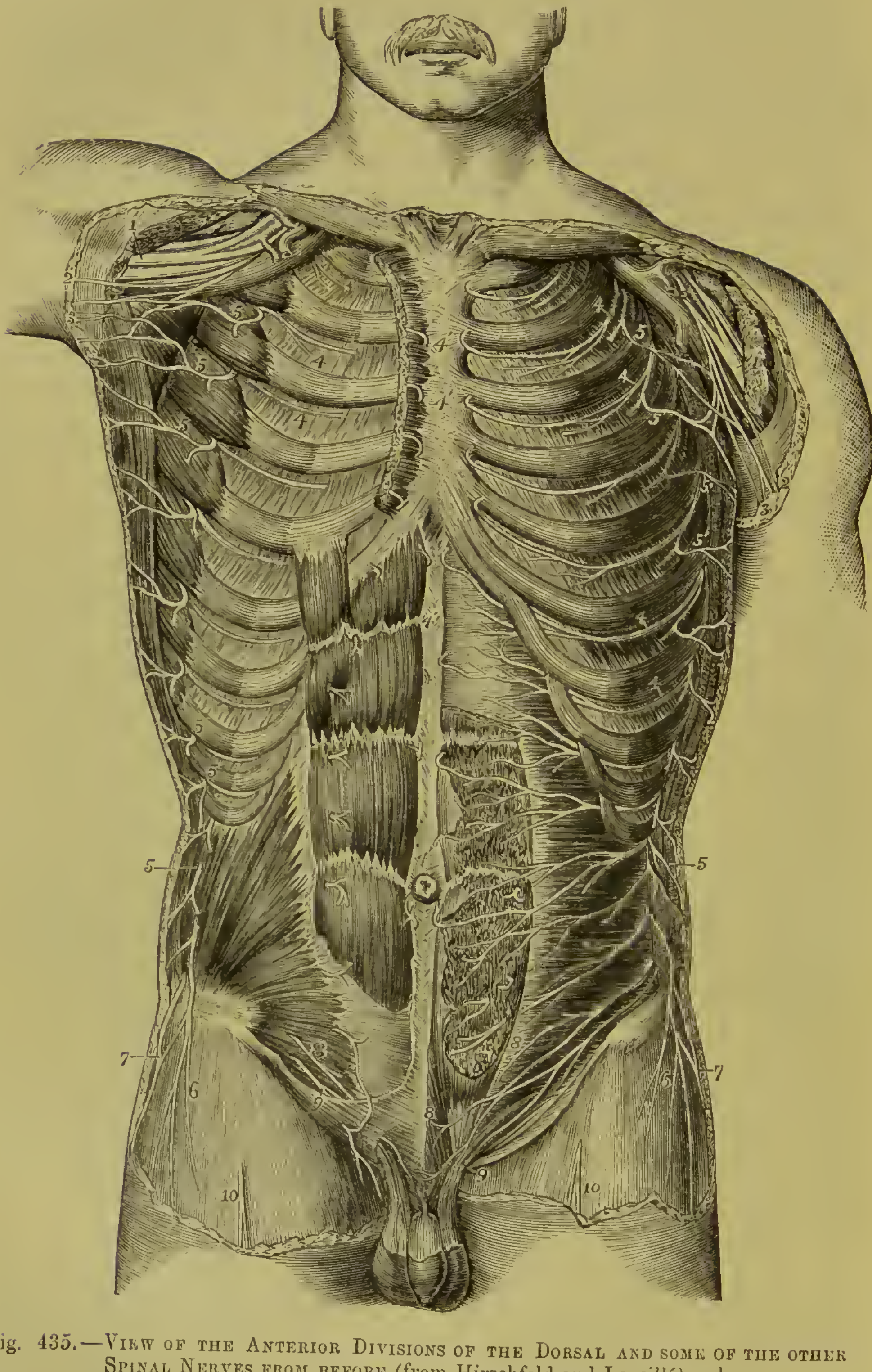


Fig. 435.—View of the Anterior Divisions of the Dorsal and some of the other Spinal Nerves from before (from Hirschfeld and Leveillé). $\frac{1}{4}$

The pectoralis major and minor muscles have been removed; on the right side the rectus abdominis and internal oblique muscles are shown, on the left side the anterior part of the rectus is cut away, and the transversalis is exposed.

1, The median and other nerves of the brachial plexus; 2, the internal cutaneous; 3,

the nerve of Wrisberg ; 4, the intercostal nerves continued forwards to 4′, their anterior cutaneous twigs ; 5, the lateral cutaneous branches of these nerves ; 6, cutaneous branch of the last dorsal spinal nerve ; 7, the iliac twig of the ilio-hypogastric branch of the first lumbar nerve ; 8, termination of the ilio-hypogastric ; 9, the ilio-inguinal ; 10, the middle cutaneous of the thigh.

the sternum, they cross the internal mammary artery and the fibres of the triangularis sterni muscle. Finally, these nerves pierce the internal intercostal muscle and the greater pectoral, and end in the integument of the breast, receiving the name of the anterior cutaneous nerves of the thorax.

At the anterior part of the chest some of the muscular twigs cross the cartilages of the ribs, passing from one intercostal space to another.

(*a*) The *lateral cutaneous nerves of the thorax* pierce the external intercostal and serratus magnus muscles, in a line a little behind the pectoral border of the axilla. The first intercostal usually gives no lateral branch or only a slender twig to the axilla, but when that of the second nerve is unusually small, it is supplemented by that of the first. The branch from the second intercostal is named intercosto-humeral, and requires separate description. Each of the remaining lateral cutaneous nerves divides into two branches, which reach the integument at a short distance from each other, and are named anterior and posterior.

The *anterior branches* are continued forwards over the border of the great pectoral muscle. Several reach the mammary gland and the nipple; and from the lower nerves twigs are supplied to the digitations of the external oblique muscle of the abdomen.

The *posterior branches* turn backwards to the integument over the scapula and the latissimus dorsi muscle. The branch from the third nerve ramifies in the axilla, and a few filaments reach the arm.

The *intercosto-humeral* nerve, the lateral cutaneous branch of the second intercostal nerve, corresponds with the posterior of the two divisions of the succeeding lateral cutaneous branches, the anterior being commonly wanting. It crosses the axillary space to reach the arm, and is connected in the axilla with an offset of the nerve of Wrisberg. Penetrating the fascia, it becomes subcutaneous, and ramifies in the integument of the upper half of the arm, on the inner and posterior aspect; a few filaments reach the integument over the scapula. The branches of this nerve cross over the internal cutaneous offset of the musculo-spiral, and a communication is established between the two nerves. The size of the intercosto-humeral nerve, and the extent of its distribution, are in the inverse proportion to the size of the other cutaneous nerves of the upper arm, especially the nerve of Wrisberg.

(*b*) The *anterior cutaneous nerves of the thorax*, which are the terminal twigs of the intercostal nerves, are reflected outwards in the integument over the great pectoral muscle. The branch from the second nerve is connected with the supraclavicular and the lateral cutaneous nerves; those from the third and fourth nerves are distributed to the mammary gland.

LOWER OR ABDOMINAL INTERCOSTAL NERVES.

The lower intercostal nerves are continued from the anterior ends of the intercostal spaces, between the internal oblique and the transverse muscle of the abdomen, to the outer edge of the rectus. Perforating the sheath, they enter the substance of that muscle, and afterwards terminate in small cutaneous branches (anterior cutaneous).

(*a*) The *lateral cutaneous nerves of the abdomen* pass to the integument through the external intercostal and external oblique muscles, in a line with the corresponding nerves on the thorax, and divide in the same manner into anterior and posterior branches.

The *anterior branches* are the larger, and are directed inwards in the superficial fascia, with small cutaneous arteries, nearly to the edge of the rectus muscle.

The *posterior branches* bend backwards over the latissimus dorsi muscle.

(*b*) The *anterior cutaneous nerves of the abdomen* become subcutaneous near the

linea alba, accompanying the small perforating arteries. Their number and position are very uncertain. They are directed outwards towards the lateral cutaneous nerves. A second set is described by Cruveilhier as existing at the outer edge of the rectus muscle.

LAST DORSAL NERVE.

The anterior primary division of this nerve is below the last rib, and is contained altogether in the abdominal wall. The nerve has the general course and distribution of the others between the internal oblique and transversalis, but before taking its place between those muscles, it passes in front of the upper part of the quadratus lumborum, and pierces the posterior aponeurosis of the transverse muscle. This nerve is connected by offsets with the nerve above, and occasionally with the ilio-hypogastric branch of the lumbar plexus. Near the spine it sometimes communicates with the first lumbar nerve by means of a small cord in the substance of the quadratus lumborum.

The *lateral cutaneous branch* of the last dorsal nerve passing through both oblique muscles, is directed downwards over the iliac crest to the integument covering the fore part of the gluteal region and the upper and outer part of the thigh, some filaments reaching as far as the great trochanter of the femur.

ANTERIOR PRIMARY DIVISIONS OF THE LUMBAR NERVES.

The anterior divisions of the lumbar nerves increase in size from the first to the fifth ; and all, except the fifth, which passes down to join the sacral nerves, are connected together by communicating loops, so as to form the lumbar plexus. On leaving the intervertebral foramina these nerves are connected by filaments with the sympathetic nerve, these filaments being longer than those connected with other spinal nerves, in consequence of the position of the lumbar sympathetic ganglia on the fore part of the bodies of the vertebræ. In the same situation are furnished small twigs to the psoas and quadratus lumborum muscles.

LUMBAR PLEXUS.

The lumbar plexus is formed by the communications between the anterior primary divisions of the four upper lumbar nerves. It is placed in the substance of the psoas muscle, in front of the transverse processes of the corresponding vertebræ. Above, the plexus is narrow, and is sometimes connected with the last dorsal nerve by a small offset from that nerve, named dorsi-lumbar ; below it is wider, and is joined to the sacral plexus by means of a branch given by the fourth lumbar nerve to the fifth.

The arrangement of the plexus may be thus stated :—The first nerve gives off the ilio-hypogastric and ilio-inguinal nerves, and sends downwards a communicating branch to the second nerve. The second furnishes the greater part of the genito-crural and external cutaneous nerves, and gives a connecting branch to the third, from which some of the fibres of the anterior crural and obturator nerves are derived. From the third nerve, besides the descending branch to the fourth, two branches proceed : one of these, the larger, forms part of the anterior crural nerve ; the other, a part of the obturator nerve. The fourth nerve gives two branches, which serve to complete the obturator and anterior crural nerves, and a connecting branch to the fifth nerve.

The *branches* of this plexus form two sets, which are distributed, one to the lower part of the wall of the abdomen, the other to the fore part and inner side of the lower limb. In the former set are the ilio-hypogastric and

Fig. 436.

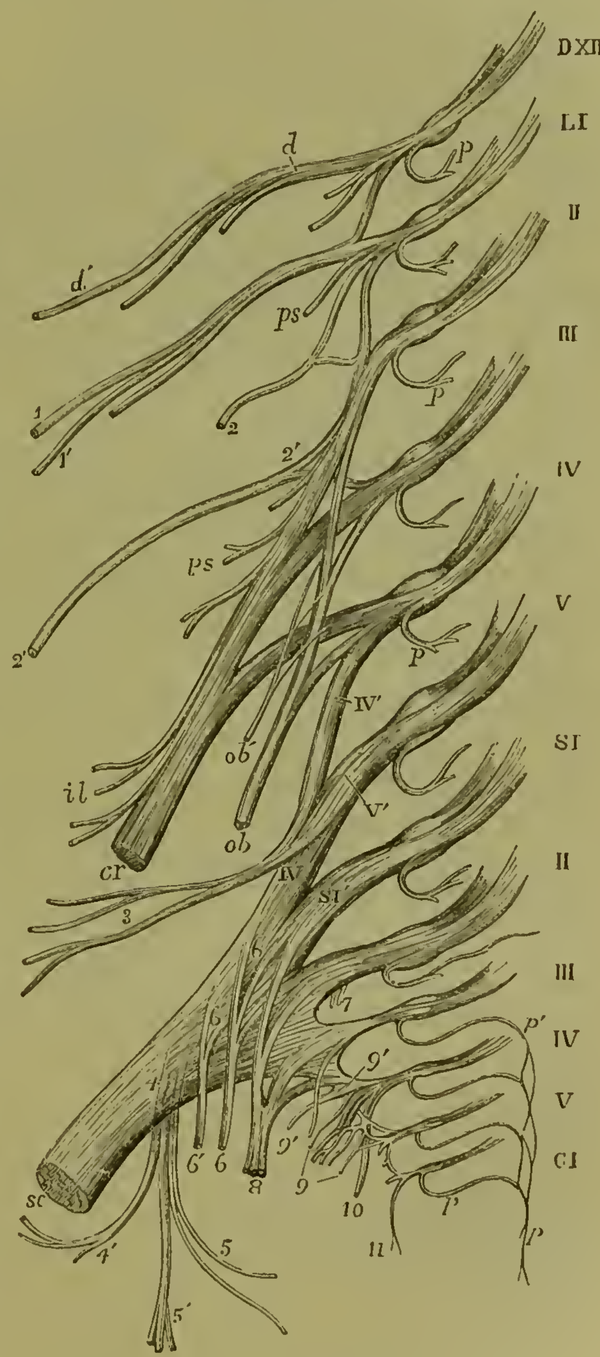


Fig. 436. — Diagrammatic Outline of the Lumbar and Sacral Plexuses with the principal Nerves arising from them. ½

DXII, placed opposite the divided roots of the last dorsal nerve ; LI to V, opposite the roots of the five lumbar nerves : the loops uniting the anterior primary divisions of these nerves together, and the first with the twelfth dorsal are shown ; SI to V, and CI, the same in the sacral and coccygeal nerves ; *p*, placed on some of the nerves marks the posterior primary divisions cut short; *p′ p*, the plexus formed by the union of the posterior branches of the third, fourth, and fifth sacral and the coccygeal nerves ; *d*, the abdominal continuation of the last dorsal nerve from which *d′*, the iliac cutaneous branch arises ; 1, 1′, the ilio-hypogastric and ilio-inguinal branches of the first lumbar nerve ; 2, the genito-crural rising by a loop from the first and second lumbar ; 2′, external cutaneous of the thigh rising by a loop from the second and third ; *ps*, branches to the psoas muscle along the lumbar plexus ; *cr*, anterior crural nerve from the second, third, and fourth lumbar ; *il*, branches to the iliacus ; *ob*, obturator nerve from the second, third and fourth lumbar nerves ; *ob′*, accessory obturator ; IV′, V′, loop from the fourth and fifth lumbar, forming the lumbo-sacral cord ; 3, superior gluteal nerve ; *sc*, sacral plexus ending in the great sciatic nerve ; 4, lesser sciatic nerve rising from the plexus posteriorly ; 4′, inferior gluteal branches ; 5, inferior pudendal ; 5′, posterior cutaneous of the thigh and leg ; 6, 6, branches to the obturator internus and gemellus superior ; 6′, 6′, branches to the gemellus inferior, quadratus and hip-joint ; 7, twigs to the pyriformis ; 8, 8, pudic nerve from the first, second, third, and fourth sacral ; 9, visceral branches ; 9′, twig to the levator ani ; 10, cutaneous from the fourth, which passes round the lower border of the gluteus maximus ; 11, coccygeal branches.

ilio-inguinal nerves, and part of the genito-crural ; and to the latter belong the remaining part of the genito-crural nerve, the external cutaneous, the obturator, and the anterior crural nerves.

ILIO-HYPOGASTRIC AND ILIO-INGUINAL NERVES.

These nerves are the upper two branches from the lumbar plexus ; they are both derived from the first lumbar nerve, and have a nearly similar distribution. They become subcutaneous by passing between the broad muscles of the abdomen, and through the outer one, and end in the integument of the groin and scrotum in the male, and the labia pudendi in the female, as well as in the integument covering the gluteal muscles. The extent of distribution of the one is inversely proportional to that of the other.

The *ilio-hypogastric* nerve, emerging from the upper part of the psoas muscle at the outer border, runs obliquely over the quadratus lumborum to the iliac crest, and there perforating the transverse muscle of the abdomen, gets between that muscle and the internal oblique, and divides into an iliac and a hypogastric branch.

(*a*) The *iliac branch* pierces the attachment of both oblique muscles, immediately above the iliac crest, and is lost in the integument over the gluteal muscles, behind the distribution of the lateral cutaneous branch of the last dorsal nerve.

(*b*) The *hypogastric* or *abdominal* branch passes on between the transverse and internal oblique muscles, and is connected with the ilio-inguinal nerve near the iliac crest. It then perforates the internal oblique muscle, and piercing the aponeurosis of the external oblique, a little above the superficial inguinal opening, is distributed to the skin of the abdomen above the pubes.

The size of the iliac branch of this nerve varies inversely with that of the lateral cutaneous branch of the twelfth dorsal. The hypogastric branch is not unfrequently joined with the last dorsal nerve between the muscles, near the crest of the innominate bone.

The *ilio-inguinal nerve*, smaller than the preceding, supplies the integument of the groin. Descending obliquely outwards over the quadratus lumborum, it crosses the fibres of the iliacus muscle, being placed lower down than the ilio-hypogastric : it then perforates the transverse muscle further forwards than the ilio-hypogastric ; communicating with that nerve between the abdominal muscles. Then piercing the internal oblique muscle, it descends in the inguinal canal, and emerging at the superficial inguinal ring, is distributed to the skin upon the groin, as well as to that upon the scrotum and penis in the male, or the labium pudendi in the female, communicating with the inferior pudendal nerve. In its progress this nerve furnishes branches to the internal oblique muscle.

The ilio-inguinal nerve occasionally arises from the loop connecting the first and second lumbar nerves. It is sometimes small, and ends near the iliac crest by joining the ilio-hypogastric nerve ; in that case the last nerve gives off an inguinal branch having a similar course and distribution to the ilio-inguinal nerve, the place of which it supplies.

GENITO-CRURAL NERVE.

The genito-crural nerve belongs partly to the external genital organs and partly to the thigh. It is derived chiefly from the second lumbar nerve, but receives also a few fibres from the connecting cord between that and the first nerve. The nerve descends obliquely through the psoas muscle, and afterwards on its fore part, towards Poupart's ligament, dividing at a variable height into an internal or genital, and an external or crural branch.

It often bifurcates close to its origin from the plexus, in which case its two branches perforate the psoas muscle in different places.

(*a*) The *genital branch* (external spermatic, Schmidt), lies upon or near the external iliac artery, and sends filaments along that vessel; then perforating the transversalis fascia, it passes through the inguinal canal with the spermatic cord, and is lost upon

Fig. 437.

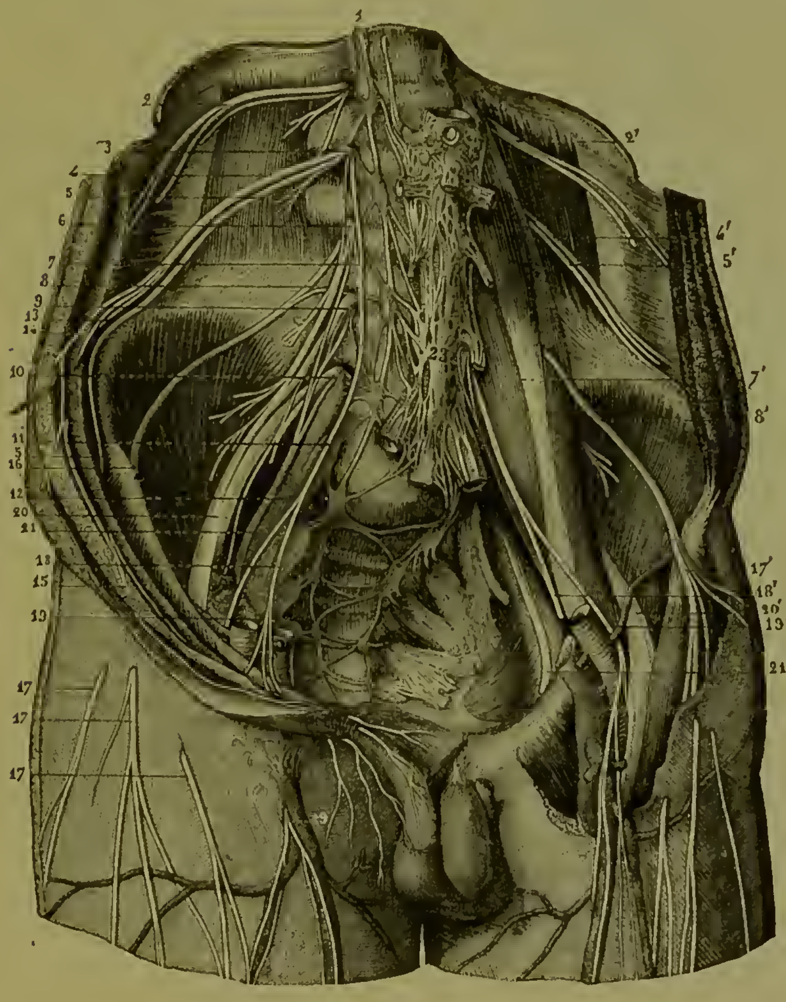


Fig. 437.—View from before of the Anterior Branches of the Lumbar and Sacral Nerves with the Plexuses (from Sappey after Hirschfeld and Leveillé). $\frac{1}{4}$

1, lumbar cord of the great sympathetic nerve; 2, 2′, antorior primary division of the twelfth dorsal nerve; 3, first lumbar; 4, 4′, ilio-inguinal branch of this nerve; 5, 5′, ilio-hypogastric branch; 6, second lumbar nerve; 7, 7′, genito-crural nerve rising from the first and second lumbar; 8, 8′, external cutaneous nerve of the thigh; 9, third lumbar nerve; 10, fourth; 11, fifth; 12, lumbo-sacral trunk; 13, iliac branch of the ilio-inguinal; 14, its abdominal branch; 15, its genital branch; 16, external cutaneous nerve of the right side passing out of the pelvis under Poupart's ligament; 17, 17, 17, cutaneous ramifications of this nerve; 17′, the same nerve exposed on the left side; 18, 18′, genital branch of the genito-crural; 19, its crural branch on the right side becoming cutaneous; 19′, the same on the left side exposed as it descends in front of the femoral artery; 20, anterior crural nerve; 21, 21′, obturator nerve; 22, left sciatic plexus; 23, aortic plexus of the sympathetic nerve connected superiorly with the other pre-aortic plexuses and the lumbar ganglia, and inferiorly with the hypogastric plexus.

the cremaster muscle. In the female it accompanies the round ligament of the uterus.

(*b*) The *crural branch* (lumbo-inguinal nerve, Schmidt), descends upon the psoas muscle beneath Poupart's ligament into the thigh. Immediately below that ligament, and at the outer side of the femoral artery, it pierces the fascia lata, and supplies the skin on the upper part of the thigh, communicating with the middle cutaneous branch of the anterior crural nerve. Whilst it is passing beneath Poupart's ligament, some filaments are prolonged from this nerve on the femoral artery. It is stated by Schmidt, that when the crural branch of the genito-crural nerve is large, and commences near the plexus, he has observed it to give a muscular branch to the lower border of the internal oblique and transversalis muscles.

EXTERNAL CUTANEOUS NERVES.

This nerve, commencing from the loop formed between the second and third lumbar nerves, on emerging from the outer border of the psoas muscle, crosses the iliacus muscle below the ilio-inguinal nerve, and passing beneath Poupart's ligament, reaches the thigh beneath the anterior superior iliac spine, where it divides into an anterior and a posterior branch distributed to the integument of the outer side of the hip and thigh.

(*a*) The *posterior branch* perforates the fascia lata, and subdivides into two or three others, which turn backwards and supply the skin upon the outer surface of the limb, from the upper border of the hip-bone nearly to the middle of the thigh. The highest among them are crossed by the cutaneous branches from the last dorsal nerve.

(*b*) An *anterior branch*, the continuation of the nerve, is at first contained in a sheath or canal formed in the substance of the fascia lata; but about four inches below Poupart's ligament, it enters the subcutaneous fatty tissue, and is distributed along the outer part of the front of the thigh, ending near the knee. The principal offsets spring from its outer side. In some cases, this branch reaches quite down to the knee, and communicates there with the internal saphenous nerve.

OBTURATOR NERVE.

The obturator nerve (internal crural) is distributed to the adductor muscles of the thigh, and to the hip and knee joints. It arises from the lumbar plexus by two roots, one from the third and the other from the fourth lumbar nerve. Having emerged from the inner border of the psoas muscle, opposite to the brim of the pelvis, it runs along the side of the pelvic cavity, above the obturator vessels, as far as the opening in the upper part of the thyroid foramen, through which it escapes from the pelvis into the thigh. Here it immediately divides into an anterior and a posterior branch, which are separated from one another by the short adductor muscle.

A.—The *anterior portion* communicates with the accessory obturator nerve, when that nerve is present, and descends in front of the adductor brevis and behind the pectineus and adductor longus muscles. It gives branches as follows :—

(*a*) An *articular branch* to the hip-joint arises near the thyroid membrane.

(*b*) *Muscular branches* are given to the gracilis and adductor longus muscles, and occasionally also others to the adductor brevis and pectineus.

(*c*) The *terminal twig* turns outwards upon the femoral artery, and surrounds that vessel with small filaments.

(*d*) An offset at the lower border of the adductor longus communicates beneath the fascia with the internal cutaneous branch of the anterior crural nerve, and with a branch of the internal saphenous nerve, forming a sort of plexus.

Occasional cutaneous nerve.—In some instances the communicating branch described

is larger than usual, and descends along the posterior border of the sartorius to the inner side of the knee, where it perforates the fascia, communicates with the internal saphenous nerve, and extends down the inner side of the limb, supplying the skin as low as the middle of the leg.

Fig. 438.

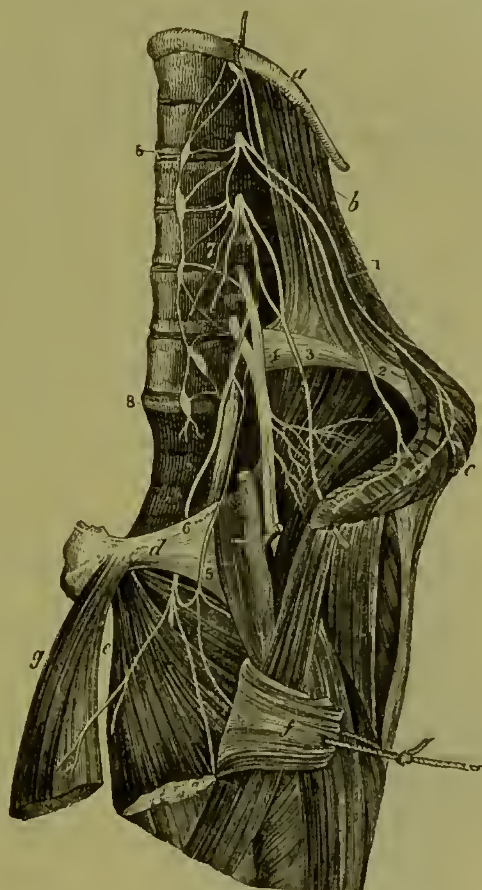


Fig. 438.—The Lumbar Plexus from before, with the Distribution of some of its Nerves (slightly altered from Schmidt). ½

a, the last rib; *b*, quadratus lumborum muscle; *c*, oblique and transverse muscles cut near the crest of the ilium and turned down; *d*, pubes; *e*, adductor brevis muscle; *f*, pectineus divided and turned outwards; *g*, adductor longus; 1, ilio-hypogastric nerve; 2, ilio-inguinal; 3, external cutaneous; 4, anterior crural; 5, accessory obturator; 6, obturator, united with the accessory by a loop round the pubes; 7, genito-crural in two branches cut short near their origin; 8, 8, lumbar portion of the gangliated sympathetic cord.

When this cutaneous branch of the obturator nerve is present, the internal cutaneous branch of the anterior crural nerve is small, the size of the two nerves bearing an inverse proportion to each other.

B.—The *posterior* or *deep* part of the obturator nerve having passed through some fibres of the external obturator muscle, crosses behind the short adductor to the fore part of the adductor magnus, where it divides into many branches, all of which enter those muscles, excepting one which is prolonged downwards to the knee-joint.

(*a*) The *muscular* branches supply the external obturator and the great adductor muscle, with the short adductor also when this muscle receives no branch from the anterior division of the nerve.

(*b*) The *articular* branch for the knee rests at first on the adductor magnus, but perforates the lower fibres of that muscle, and thus reaches the upper part of the popliteal space. Supported by the popliteal artery, and sending filaments around that vessel, the nerve then descends to the back of the knee-joint, and enters the articulation through the posterior ligament. (Thomson, "London Med. and Surg. Journal," No. xcv.)

ACCESSORY OBTURATOR NERVE.

The accessory obturator nerve, a small and inconstant nerve, arising from the obturator nerve near its upper end, or separately from the same nerves of the plexus, descends along the inner border of the psoas muscle, over the pubic bone, and passing behind the pectineus muscle, ends by dividing into several branches. Of these one joins the anterior branch of the obturator nerve; another penetrates the pectineus on the under surface; whilst a third enters the hip-joint with the articular artery.

This nerve is sometimes smaller than usual, and ends in filaments which perforate the capsule of the hip-joint. When it is altogether wanting, the hip-joint receives branches from the obturator nerve.

Summary.—The obturator nerve and accessory obturator give branches to the hip and knee joints, also to the adductor muscles of the thigh, and, in some cases, to the pectineus. Occasionally a cutaneous branch descends to the inner side of the thigh, and to the inner and upper part of the leg.

ANTERIOR CRURAL NERVE.

This nerve is the largest branch of the lumbar plexus, and is derived principally from the third and fourth lumbar nerves, but in part also from the second. Emerging from the outer border of the psoas muscle, near its lower part, it descends into the thigh in the groove between that muscle and the iliacus, and, therefore, to the outside of the femoral blood-vessels. It now becomes flattened out and divides into two parts, one of which is cutaneous, while the other is distributed to muscles.

Fig. 439.

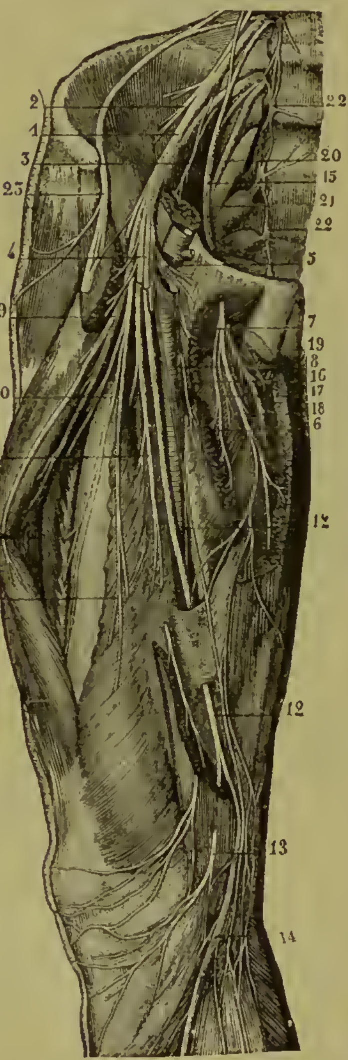


Fig. 439.—Deep Nerves of the Anterior and Inner part of the Thigh (from Sappey after Hirschfeld and Leveillé). $\frac{1}{5}$

1, anterior crural nerve; 2, branches given to the iliacus muscle; 3, branch to the lower part of the psoas; 4, large musculo-cutaneous branches divided to show the deeper nerves; 5 and 6, muscular filaments from the small musculo-cutaneous; 7, origin of the cutaneous branches; 8, communicating filament of the internal cutaneous nerves; 9, branches to the rectus; 10, branches to the vastus externus; 11, branches to the vastus internus; 12, internal saphenous nerve; 13, its patellar branch; 14, its continuation down the leg: 15, obturator nerve; 16, branch from the obturator nerve to the adductor longus; 17, branch to the adductor brevis; 18, branch to the gracilis; from this a filament is prolonged downwards, to unite with the plexus formed by the union of branches from the internal cutaneous and internal saphenous nerves; 19, deep branch of the obturator nerve to the adductor magnus; 20, lumbo-sacral trunk; 21, its union with the first sacral nerve; 22, 22, lumbar and sacral part of the sympathetic nerve; 23, external cutaneous nerve from the lumbar plexus.

Branches of the trunk.—The branches given from the anterior crural nerve within the abdomen are few and of small size.

(*a*) The *iliacus* receives three or four small branches, which are directed outwards from the nerve to the fore part of the muscle.

(*b*) The *nerve of the femoral artery* is a small branch which divides into numerous filaments upon the upper part of that vessel. It sometimes arises lower down than usual in the thigh. It may, on the other hand, be found to take origin above the ordinary position; and in this case it proceeds from the middle cutaneous nerve,

when that branch springs from or near the lumbar plexus. In either case, its ultimate distribution is the same as that already described.

Terminal branches.—From the principal or terminal divisions of the nerve the remaining branches take their rise as follows :—

From the SUPERFICIAL DIVISION cutaneous branches are given to the fore part of the thigh, and to the inner side of the leg. They are the middle and internal cutaneous nerves, and the internal saphenous nerve. One of the muscles, the sartorius, receives its nerves from this group.

The DEEP BRANCHES supply the muscles on the fore part of the thigh, and also the pectineus muscle. The branch to the pectineus, however, sometimes arises from the superficial part of the trunk.

A. MUSCULAR BRANCHES.

The branch to the *pectineus* muscle crosses inwards behind the femoral vessels, and enters the muscle on the anterior aspect.

The *sartorius* muscle receives three or four twigs, which arise in common with the cutaneous nerves, and reach mostly the upper part of the muscle.

The *rectus* muscle receives a distinct branch on its under surface.

The nerve for the *vastus externus*, of considerable size, descends with the branches of the external circumflex artery towards the lower part of the muscle. It gives off a long slender *articular* filament, which reaches the knee and penetrates the fibrous capsule of the joint.

Another large nerve divides into two sets of branches, which enter the *vastus internus* and the *crureus* about the middle of those muscles. The nerve of the vastus internus, before penetrating the muscular fasciculi, gives a small branch to the knee-joint. This *articular* nerve passes along the internal intermuscular septum with a branch of the anastomotic artery, as far as the inner side of the joint, where it perforates the capsular ligament, and is directed outwards on the synovial membrane beneath the ligamentum patellæ.

B. MIDDLE CUTANEOUS NERVE.

The middle cutaneous nerve either pierces the fascia lata divided into two branches about four inches below Poupart's ligament, or as one trunk which soon separates into two branches. These branches descend side by side on the fore part of the thigh to the inner side and front of the patella. After or before the nerve has become subcutaneous, it communicates with the crural branch of the genito-crural nerve, and also with the internal cutaneous.

This nerve sometimes arises from the anterior crural, high up within the abdomen.

C. INTERNAL CUTANEOUS NERVE.

The internal cutaneous nerve gives branches to the skin on the inner side of the thigh, and the upper part of the leg ; but the extent to which it reaches varies with the presence or absence of the "occasional cutaneous" branch of the obturator nerve.

Lying beneath the fascia lata, this nerve descends obliquely over the upper part of the femoral artery. It divides either in front of that vessel, or at the inner side, into two branches (one anterior, the other internal), which pierce the fascia separately. These two branches sometimes arise as distinct offsets from the superficial part of the anterior crural nerve.

The distribution of the internal cutaneous nerve is as follows :—

(*a*) *Branches previous to division.*—Before dividing into its two ultimate branches, this nerve gives off two or three cutaneous twigs, which accompany the upper part of the long saphenous vein. The highest of these perforates the fascia

near the saphenous opening, and reaches down to the middle of the thigh. The others appear beneath the skin lower down by the side of the vein; one, larger than the rest, passes through the fascia about the middle of the thigh, and extends to the knee. In some instances, these small branches spring directly from the anterior crural nerve, and they often communicate with each other.

Fig. 440.

Fig. 440.—Cutaneous Nerves of the Anterior and Inner Part of the Thigh (from Sappey after Hirschfeld and Leveillé). $\frac{1}{8}$

1, external cutaneous nerve; 2, 2, middle cutaneous branch of the anterior crural passing through the sartorius muscle and the fascia; 3, 3, anterior division of the internal cutaneous; 4, filament to the sartorius; 5, inner or posterior division of the internal cutaneous; 6, its superficial branch to the inside of the knee after perforating the fascia; 7, deep or communicating branch; 8, superficial branch of the musculo-cutaneous of the crural; 9, patellar branch of the internal saphenous nerve; 10, continuation of the saphenous down the leg.

(*b*) The *anterior branch*, descending in a straight line to the knee, perforates the fascia lata in the lower part of the thigh; it afterwards runs down near the intermuscular septum, giving off filaments on each side to the skin, and is finally directed over the patella to the outer side of the knee. It communicates above the joint with a branch of the long saphenous nerve; and sometimes it takes the place of the branch usually given by the latter to the integument over the patella.

This branch of the internal cutaneous nerve sometimes lies above the fascia in its whole length. It occasionally gives off a cutaneous filament, which accompanies the long saphenous vein, and in some cases it communicates with the branch to be next described.

The *inner branch* of the internal cutaneous nerve, descending along the posterior border of the sartorius muscle, perforates the fascia lata at the inner side of the knee, and communicates by a small branch with the internal saphenous nerve, which here descends in front of it. It gives some cutaneous filaments to the lower part of the thigh on the inner side, and is distributed to the skin upon the inner side of the leg. Whilst beneath the fascia, this branch of the internal cutaneous nerve joins in an interlacement with offsets of the obturator nerve below the middle of the thigh, and with the branch of the saphenous nerve nearer the knee.

D. INTERNAL SAPHENOUS NERVE.

The internal or long saphenous nerve is the largest of the cutaneous branches of the anterior crural nerve. In some cases it arises in connection with one of the deep or muscular branches.

This nerve is deeply placed as far as the knee, and is subcutaneous in the rest of its course. In the thigh it accompanies the femoral vessels, lying at first somewhat to their outer side, but lower down approaching close to

them, and passing beneath the same aponeurosis. When the vessels pass through the opening in the adductor muscle into the popliteal space, the saphenous nerve separates from them, and is continued downwards beneath the sartorius muscle to the inner side of the knee; where, having first given off, as it lies near the inner condyle of the femur, a branch which is distributed over the front of the patella, it becomes subcutaneous by piercing the fascia between the tendons of the sartorius and gracilis muscles.

The nerve then accompanies the saphenous vein along the inner side of the leg, and passing in front of the ankle is distributed to the inner side of the foot. In the leg it is connected with the internal cutaneous nerve.

The distribution of the branches is as follows:—

(*a*) A *communicating branch* is given off about the middle of the thigh to join in the interlacement formed beneath the fascia lata by this nerve and branches of the obturator and internal cutaneous nerves. After it has left the aponeurotic covering of the femoral vessels, the internal saphenous nerve has, in some cases, a further connection with one or other of the nerves just referred to.

(*b*) The *branch to the integument in front of the patella* perforates the sartorius muscle and the fascia lata; and, having received a communicating offset from the internal cutaneous nerve, spreads out upon the fore part of the knee; and, by uniting with branches of the middle and external cutaneous nerves, forms a plexus,—plexus patellæ.

(*c*) A branch to the inner ankle is given off in the lower third of the leg, and descends along the margin of the tibia.

(*d*) Filaments from this nerve enter the tarsal ligaments.

Summary.—The anterior crural nerve is distributed to the skin upon the fore part and inner side of the thigh, commencing below the termination of the ilio-inguinal and genito-crural nerves. It furnishes also a cutaneous nerve to the inner side of the leg and foot. All the muscles on the front and outer side of the thigh receive their nerves from the anterior crural, and the pectineus is also in part supplied by this nerve, and in part by the obturator. The tensor muscle of the fascia lata is supplied from a different source, viz., the superior gluteal nerve. Lastly, two branches are given from the anterior crural nerve to the knee-joint.

FIFTH LUMBAR NERVE.

The anterior branch of the fifth lumbar nerve, having received a fasciculus from the nerve next above it, descends to join the first sacral nerve, and form part of the sacral plexus. The cord resulting from the union of the fifth with a part of the fourth nerve, is named the *lumbo-sacral* nerve.

SUPERIOR GLUTEAL NERVE.

Before joining the first sacral nerve the lumbo-sacral cord gives off from behind the superior gluteal nerve; this offset leaves the pelvis through the large sacro-sciatic foramen, above the pyriformis muscle, and divides like the gluteal artery into two branches, which are distributed chiefly to the smaller gluteal muscles and tensor of the fascia lata.

(*a*) The *upper* branch runs with the gluteal artery along the origin of the gluteus minimus, and is lost in it and in the gluteus medius.

(*b*) The *lower* branch crosses over the middle of the gluteus minimus, between this and the gluteus medius, and supplying filaments to both those muscles, is continued forwards, and terminates in the tensor muscle of the fascia lata.

ANTERIOR PRIMARY DIVISIONS OF THE SACRAL AND COCCYGEAL NERVES.

THE SACRAL NERVES.

The anterior divisions of the first four sacral nerves emerge from the spinal canal by the anterior sacral foramina, and the fifth passes out between the sacrum and coccyx.

The first two sacral nerves are large, and of nearly equal size; the others diminish rapidly, and the fifth is exceedingly slender. Like the anterior divisions of the other spinal nerves, those of the sacral nerves communicate with the sympathetic: the communicating cords are very short, as the sympathetic ganglia are close to the inner margin of the foramina of the sacrum.

The first three nerves and part of the fourth contribute to form the sacral plexus. The fifth has no share in the plexus,—it ends on the back of the coccyx. As the description of the fourth and fifth sacral nerves and of the coccygeal will occupy only a short space, these three nerves may be noticed first, before the other nerves and the numerous branches to which they give rise are described.

THE FOURTH SACRAL NERVE.

Only one part of the anterior division of this nerve joins the sacral plexus; the remainder, which is nearly half the nerve, supplies branches to the viscera and muscles of the pelvis, and sends downwards a connecting filament to the fifth nerve.

(*a*) The *visceral branches* of the fourth sacral nerve are directed forwards to the lower part of the bladder, and communicate freely with branches from the sympathetic nerve. Offsets are distributed to the neighbouring viscera, according to the sex. They will be described with the pelvic portion of the sympathetic nerve. The foregoing branches are, in some instances, furnished by the third sacral nerve instead of the fourth, and not unfrequently from both of these nerves.

(*b*) Of the *muscular branches,* one supplies the *levator ani,* piercing that muscle on the pelvic surface; another enters the *coccygeus,* whilst a third ends in the *external sphincter* muscle of the rectum. The last branch, after passing either through the coccygeus, or between it and the levator ani, reaches the perinæum, and is distributed likewise to the integuments between the anus and the coccyx.

THE FIFTH SACRAL NERVE.

The anterior branch of this, the lowest sacral nerve, comes forwards through the coccygeus muscle opposite the junction of the sacrum with the first coccygeal vertebra; it then descends upon the coccygeus nearly to the tip of the coccyx, where it turns backwards through the fibres of that muscle, and ends in the integument upon the posterior and lateral aspect of the bone.

As soon as this nerve appears in front of the bone (in the pelvis) it is joined by the descending filament from the fourth nerve, and lower down by the small anterior division of the coccygeal nerve. It supplies small filaments to the coccygeus muscle.

THE COCCYGEAL NERVE.

The anterior branch of the coccygeal, or, as it is sometimes named, the sixth sacral nerve, is a very small filament. It escapes from the spinal

canal by the terminal opening, pierces the sacro-sciatic ligament and the coccygeus muscle, and being joined upon the side of the coccyx with the fifth sacral nerve, partakes in the distribution of that nerve.

THE SACRAL PLEXUS.

The lumbo-sacral cord (resulting as before described from the junction of the fifth and part of the fourth lumbar nerves), the anterior divisions of the first three sacral nerves, and part of the fourth, unite to form this plexus. Its construction differs from that of the other spinal nervous plexuses in this respect, that the several constituent nerves entering into it

Fig. 441.

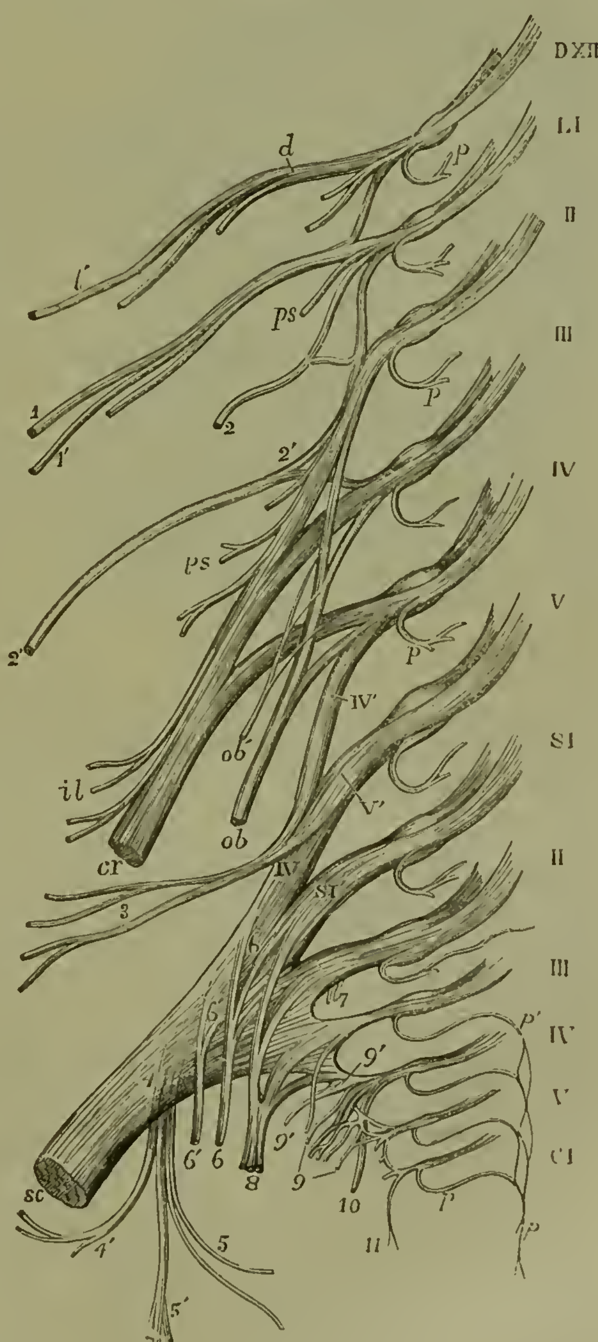


Fig. 441. — Diagrammatic Outline of the Lumbar and Sacral Plexuses with the principal Nerves arising from them. $\frac{1}{2}$

The references to the nerves of the lumbar plexus will be found at p. 658. DXII, roots of the last dorsal nerve; LI to V, roots of the five lumbar nerves; SI to V, and CI, roots of the five sacral and the coccygeal nerves; IV′, V′, loop from the anterior primary branches of the fourth and fifth lumbar nerves, forming the lumbo-sacral cord; 3, superior gluteal nerve; SC, sacral plexus ending in the great sciatic nerve; 4, lesser sciatic nerve, rising from the plexus posteriorly; 4′, inferior gluteal branches; 5, inferior pudendal; 5′, posterior cutaneous of the thigh and leg; 6, 6, branches to the obturator internus and gemellus superior; 6′, 6′, branches to the gemellus inferior, quadratus and hip-joint; 7, twigs to the pyriformis; 8, 8, pudic from the first, second, third, and fourth sacral; 9, visceral branches; 9′, twig to the levator ani; 10, cutaneous from the fourth, which passes round the lower border of the gluteus maximus; 11, coccygeal branches.

unite into one broad flat cord. To the place of union the nerves proceed in different directions, that of the upper ones being obliquely downwards, while that of the lower is nearly horizontal; and, as a consequence of this difference, they diminish in length from the first to the last. The sacral plexus rests on the anterior surface of the pyriform muscle, opposite the side of the sacrum, and escaping through the great sacro-sciatic foramen, ends in the great sciatic nerve.

Branches.—The sacral plexus gives rise to the great sciatic nerve, and to various smaller branches; viz., the pudic nerve, the small sciatic nerve, and branches to the obturator internus, pyriformis, gemelli, and quadratus femoris muscles.

MUSCULAR BRANCHES.

a. To *the pyriformis muscle*, one or more branches are given, either from the plexus or from the upper sacral nerves before they reach the plexus.

b. The *nerve of the internal obturator muscle* arises from the part of the plexus formed by the union of the lumbo-sacral and the first sacral nerves. It turns over the ischial spine of the hip-bone with the pudic vessels, and is then directed forwards through the small sacro-sciatic foramen to reach the inner surface of the obturator muscle.

c. To the *levator ani* one or more twigs proceed from the lower part of the plexus.

d. The *superior gemellus* receives a small branch, which arises from the lower part of the plexus.

e. The small nerve which supplies *the lower gemellus* and *quadratus femoris* muscles springs from the lower part of the plexus. Concealed at first by the great sciatic nerve, it passes beneath the gemelli and the tendon of the internal obturator,—between those muscles and the capsule of the hip-joint,—and reaches the deep (anterior) surface of the quadratus. It furnishes a small articular filament to the back part of the hip-joint.

THE PUDIC NERVE.

This nerve, arising from the lower part of the sacral plexus, turns over the spine of the ischium, and then passes forwards through the small sacro-sciatic foramen, where it usually gives off the inferior hæmorrhoidal branch. It is next directed along the outer part of the ischio-rectal fossa, in a sheath of the obturator fascia, along with the pudic vessels, and divides into two terminal branches, the perinæal nerve and the dorsal nerve of the penis.

A.—The *perinæal nerve*, the lower and much the larger of the two divisions of the pudic nerve, lies below the pudic artery, and is expended in superficial and muscular branches.

a. The *superficial perinæal* branches are two in number, anterior and posterior. The *posterior* branch, which first separates from the perinæal nerve, reaching the back part of the ischio-rectal fossa, gives filaments inwards to the skin in front of the anus, and turns forwards in company with the anterior branch to reach the scrotum. The *anterior* branch descends to the fore part of the ischio-rectal fossa; and, passing forwards with the superficial perinæal artery, ramifies in the skin on the fore part of the scrotum and on the penis. This branch sends small twigs to the levator ani muscle. The superficial perinæal nerves are accompanied to the scrotum by the inferior pudendal branch of the small sciatic nerve. The three branches are sometimes named *long scrotal nerves*.

In the female, both the superficial perinæal branches terminate in the external labium pudendi.

b. The *muscular branches* generally arise by a single trunk, which is directed inwards under cover of the transversalis perinæi muscle, and divides into offsets which

are distributed to the transversalis perinæi, erector penis, accelerator urinæ, and compressor urethræ.

c. Slender filaments are sent inwards to the corpus spongiosum urethræ; some of these before penetrating the erectile tissue, run a considerable distance over its surface.

Fig. 442.

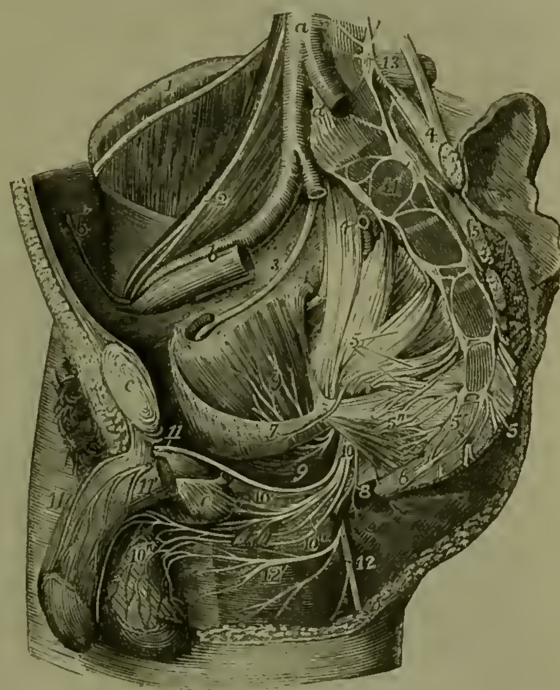


Fig. 442.—Right Side of the Interior of the Male Pelvis, with the Principal Nerves displayed (from Hirschfeld and Leveillé). ½

The left wall has been removed as far as the sacrum behind and the symphysis pubis in front; the viscera and the lower part of the levator ani have been removed; *a*, the lower part of the aorta; *a′*, placed on the fifth lumbar vertebra, between the two common iliac arteries, of which the left is cut short; *b*, the right external iliac artery and vein; *c*, the symphysis pubis; *d*, the divided pyriformis muscle, close to the left auricular surface of the sacrum; *e*, bulb of the urethra covered by the accelerator urinæ muscle; the membranous part of the urethra cut short is seen passing into it; 1, placed on the crest of the ilium points to the external cutaneous nerve of the thigh passing over the iliacus muscle; 2, placed on the psoas muscle points to the genito-crural nerve; 3, obturator nerve; 4, 4, placed on the lumbo-sacral cords; that of the right side points to the gluteal artery cut short; 4′, the superior gluteal nerve; 5, placed on the inside of the right sacral plexus, points by four lines to the anterior divisions of the four upper sacral nerves, which, with the lumbo-sacral cord, unite in the plexus; 5′, placed on the fifth piece of the sacrum, points to the fifth sacral nerves; 5″, the visceral branches proceeding from the third and fourth sacral nerves; 6, placed on the lower part of the coccyx, below the coccygeal nerves; 7, placed on the line of division of the pelvic fascia, points to the nerve of the levator ani muscle; 8, placed at the lower border of the great sacro-sciatic ligament, points to the cutaneous nerves of the anus; 9, nerve of the obturator internus; 10, the pudic nerve; 10′, is placed above the muscular branches of the perineal nerve; 10″, the anterior and posterior superficial perineal nerves, and on the scrotum the distribution of these nerves and the inferior pudendal nerve; 11, the right dorsal nerve of the penis; 11′, the nerve on the left crus penis which is cut short; 12, the continuation of the lesser sciatic nerve on the back of the thigh; 12′, the inferior pudendal branch; 13, placed on the transverse process of the fifth lumbar vertebra, marks the lowest lumbar sympathetic ganglion; 14, placed on the body of the first piece of the sacrum, points to the upper sacral sympathetic ganglia; between 14 and 6, are seen the remaining ganglia and sympathetic nervous cords, as well as their union with the sacral and coccygeal nerves, and at 6, the lowest ganglion or ganglion impar.

B.—The *dorsal nerve of the penis*, the upper division of the pudic nerve, accompanies the pudic artery in its course between the layers of the deep perinæal or sub-pubic fascia, and afterwards through the suspensory ligament, to reach the dorsum of the penis, along which it passes as far as the glans, where it divides into filaments for the supply of that part. On

the penis, this nerve is joined by branches of the sympathetic system, and it sends outwards numerous offsets to the integument on the upper surface and sides of the organ, including the prepuce. One large branch penetrates the corpus cavernosum penis.

In the female, the dorsal nerve of the clitoris is much smaller than the corresponding branch in the male; it is similarly distributed.

C.—The *inferior hæmorrhoidal* nerve arises from the pudic nerve at the back of the pelvis, or it may come directly from the sacral plexus, and be transmitted through the small sacro-sciatic foramen to its distribution in the lower end of the rectum.

Fig. 443.

Fig. 443.—Dissection of the Perinæum of the Male to show the Distribution of the Pudic and other Nerves (from Hirschfeld and Leveillé). $\frac{1}{4}$

On the right side a part of the gluteus maximus muscle and the great sacro-sciatic ligament have been removed to show the descent of the nerves from the great sacro-sciatic foramen. 1, great sciatic nerve of the right side; 2, lesser sciatic nerve; 2′, its muscular branches to the gluteus maximus (right side); 2″, cutaneous branches to the buttock (left side); 3, continuation of the nerve as posterior middle cutaneous of the thigh; 3′, internal and external cutaneous branches; 4, 4, inferior pudendal branch; 4′, network of this and the perineal nerves ou the scrotum; 5, right pudic nerve; 6, superior branch or nerve to the penis; 7, the external superficial perineal branch; 7′, the internal superficial perineal branch; 8, musculo-bulbal branches; 9, hemorrhoidal or cutaneous anal brauches; 10, cutaneous branch of the fourth sacral nerve.

Some of the branches of this nerve end in the external sphincter and in the adjacent skin of the anus; others reach the skin in front of that part, and communicate with the inferior pudendal branch of the small sciatic nerve, and with the superficial perineal nerves.

Summary.—The pudic nerve supplies the perinæum, the penis, and part of the scrotum, also the urethral and anal muscles in the male; and the

clitoris, labia, and other corresponding parts in the female. It communicates with the inferior pudendal branch of the small sciatic nerve.

SMALL SCIATIC NERVE.

The small sciatic nerve (nervus ischiadicus minor) is chiefly a cutaneous nerve, supplying the integument of the lower part of the buttock, the back of the thigh, and upper part of the calf of the leg; it furnishes also branches to one muscle—the gluteus maximus.

This nerve is formed by the union of two or more nervous cords, derived from the lower and back part of the sacral plexus. Arising below the pyriform muscle, it descends beneath the gluteus maximus, and at the lower border of that muscle comes into contact with the fascia lata. Continuing its course downwards along the back of the limb, it perforates the fascia a little below the knee.

Fig. 444.

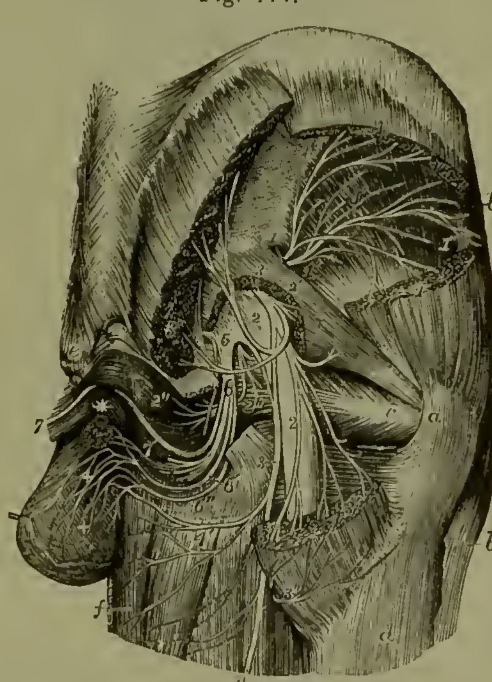


Fig. 444.—Deep Nerves in the Gluteal and Inferior Pudendal Regions (from Hirschfeld and Leveillé). ¼

a, back part of the great trochanter; *b*, tensor vaginæ femoris muscle; *c*, tendon of the obturator internus muscle near its insertion; *d*, upper part of the vastus externus; *e*, coccyx; *f*, gracilis muscle; between *f* and *d*, the adductor magnus, semitendinosus and biceps muscles; * placed at the meeting of the crura penis above the urethra; 1, placed upon the ilium close above the sacro-sciatic notch, marks the superior gluteal nerve, and on the divided parts of the gluteus medius muscle, the superior branch of the nerve; 1′, on the surface of the gluteus minimus muscle, the inferior branch of the nerve; 1″, branch of the nerve to the tensor vaginæ femoris; 2, sacral plexus and great sciatic nerve; 2′, muscular twig from the plexus to the pyriformis; 2″, muscular branches to the gemellus superior and obturator internus; 3, lesser sciatic nerve; 3′, placed on the upper and lower parts of the divided gluteus maximus, the inferior gluteal muscular branches of the lesser sciatic nerve; 3″, the cutaneous branches of the same nerve winding round the lower border of the gluteus maximus; 4, the continuation of the lesser sciatic nerve as posterior cutaneous nerve of the thigh; 4′, inferior pudendal branch of the lesser sciatic; 5, placed on the lower part of the sacral plexus, points to the origin of the pudic nerve; 6, its perineal division with its muscular branches; 6′, anterior or superior superficial perineal branch; 6″, posterior or inferior superficial perineal; + +, distribution of these nerves and the inferior pudendal on the scrotum; 7, dorsal nerve of the penis.

The *branches* of the small sciatic nerve are as follows :—

A. The *inferior gluteal* branches, given off under the gluteus maximus, supply the lower part of that muscle.—A distinct gluteal branch commonly proceeds from the sacral plexus to the upper part of the muscle.

B. The *cutaneous branches* of the nerve principally emerge from beneath the lower border of the gluteus maximus, arranged in an external and an internal set. Others appear lower down.

a. The *internal* are mostly distributed to the skin of the inner side of the thigh at the upper part. One branch, however, which is much larger than the rest, is distinguished as the inferior pudendal.

Fig. 445.

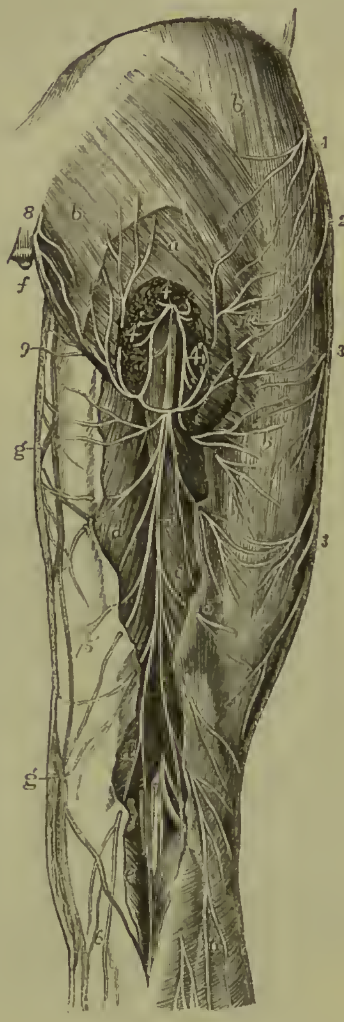


Fig. 446.

Fig. 445.—Posterior Cutaneous Nerves of the Hip and Thigh (from Hirschfeld and Leveillé). $\frac{1}{5}$

a, gluteus maximus muscle partially uncovered by the removal of a part of the fascia lata, and divided at its inferior part to show the lesser sciatic nerve ; *b*, fascia lata over the glutei muscles and the outer part of the hip ; *c*, *d*, part of the semitendinosus, biceps and semimembranosus muscles exposed by the removal of the fascia ; *e*, gastrocnemius ; *f*, coccyx ; *g*, internal branches of the saphena vein ; 1, iliac cutaneous branches of the ilio-inguinal and ilio-hypogastric nerves ; 2, cutaneous iliac branches of the last intercostal ; 3, posterior twigs of the external cutaneous nerve of the thigh ; 4, lesser sciatic nerve issuing from below the gluteus maximus muscle ; 4′, its muscular branches ; 4″, its cutaneous gluteal branches ; 5, posterior middle cutaneous continued from the lesser sciatic ; 5′, 5′, its inner and outer branches spreading on the fascia of the thigh ; 6, 6, its terminal branches descending on the calf of the leg ; 7, posterior tibial and fibular nerves separating in the popliteal space ; 8, lower posterior divisions of the sacral and coccygeal nerves ; 9, inferior pudendal nerve.

Fig. 446.—Deep Posterior Nerves of the Hip and Thigh (from Hirschfeld and Leveillé). $\frac{1}{5}$

a, gluteus medius muscle ; *b*, gluteus maximus ; *c*, pyriformis ; *d*, placed on the

trochanter major, points to the tendon of the obturator internus; *e*, upper part of the femoral head of the biceps; *f*, semitendinosus; *g*, semimembranosus; *h*, gastrocnemius; *i*, popliteal artery; 1, placed on the gluteus minimus muscle, points to the superior gluteal nerves; 2, inferior gluteal branches of the lesser sciatic; 3, placed on the greater sacro-sciatic ligament, points to the pudic nerve; 3′, its farther course; 4, inferior pudendal; 5, placed on the upper divided part of the semitendinosus and biceps, points to the posterior middle cutaneous nerve of the thigh; 6, great sciatic nerve, 6′, 6′, some of its muscular branches to the flexors; 7, internal popliteal or posterior tibial nerve; 7′, its muscular or sural branches; 8, external popliteal or peroneal nerve; 8′, its external cutaneous branch; 9, communicating tibial; 9′, communicating peroneal branch to the external saphenous nerve.

The *inferior pudendal* branch turns forwards below the ischial tuberosity to reach the perinæum. Its filaments then extend forwards to the front and outer part of the scrotum, and communicate with one of the superficial perineal nerves. In the female, the inferior pudendal branch is distributed to the external labium pudendi.

b. The *external* cutaneous branches, two or three in number, turn upwards in a retrograde course to the skin over the lower and outer part of the great gluteal muscle. In some instances one takes a different course, descending and ramifying in the integuments on the outer side of the thigh nearly to the middle.

c. Of the *lower branches* some small cutaneous filaments pierce the fascia of the thigh above the popliteal space. One of these, arising somewhat above the knee-joint, is prolonged over the popliteal region to the upper part of the leg.

Of the *terminal twigs*, perforating the fascia lata opposite the lower part of the popliteal space, one accompanies the short saphenous vein beyond the middle of the leg, and others pass into the integument covering the inner and outer heads of the gastrocnemius muscle. Its terminal cutaneous branches communicate with the short saphenous nerve.

GREAT SCIATIC NERVE.

The great sciatic nerve (nervus ischiadicus), the largest nerve in the body, supplies the muscles at the back of the thigh, and by its branches of continuation gives nerves to all the muscles below the knee and to the greater part of the integument of the leg and foot. The several joints of the lower limb receive filaments from it and its branches.

This large nerve is continued from the lower end of the sacral plexus. It escapes from the pelvis through the great sacro-sciatic foramen, below the pyriformis muscle, and reaches down below the middle of the thigh, where it separates into two large divisions, named the *internal* and *external popliteal* nerves. At first it lies in the hollow between the great trochanter and the ischial tuberosity, covered by the gluteus maximus and resting on the gemelli, obturator internus and quadratus femoris muscles, in company with the small sciatic nerve and the sciatic artery, and receiving from that artery a branch which runs for some distance in its substance. Lower down it rests on the adductor magnus, and is covered behind by the long head of the biceps muscle.

The bifurcation of the sciatic nerve may take place at any point intermediate between the sacral plexus and the lower part of the thigh; and, occasionally, it is found to occur even within the pelvis, a portion of the pyriformis muscle being interposed between the two great divisions of the nerve.

Branches of the trunk.—In its course downwards, the great sciatic nerve supplies offsets to some contiguous parts, viz., to the hip-joint, and to the muscles at the back of the thigh.

a. The *articular branches* are derived from the upper end of the nerve, and enter the capsular ligament of the hip-joint, on the posterior aspect. They sometimes arise from the sacral plexus.

b. The *muscular branches* are given off under cover of the biceps muscle; they supply the flexors of the leg, viz., the biceps, semitendinosus, and semimembranosus. A branch is likewise given to the adductor magnus.

INTERNAL POPLITEAL NERVE.

The internal popliteal nerve, the larger of the two divisions of the great sciatic nerve, following the same direction as the parent trunk, continues along the middle of the popliteal space to the lower border of the popliteus muscle, beneath which point the continuation of the trunk receives the name of *posterior tibial.* The internal popliteal nerve lies at first at a considerable distance from the popliteal artery, at the outer side and nearer to the surface; but, from the knee-joint downwards, the nerve, continuing a straight course, is close behind the artery, and then crosses it rather to the inner side.

Fig. 447.

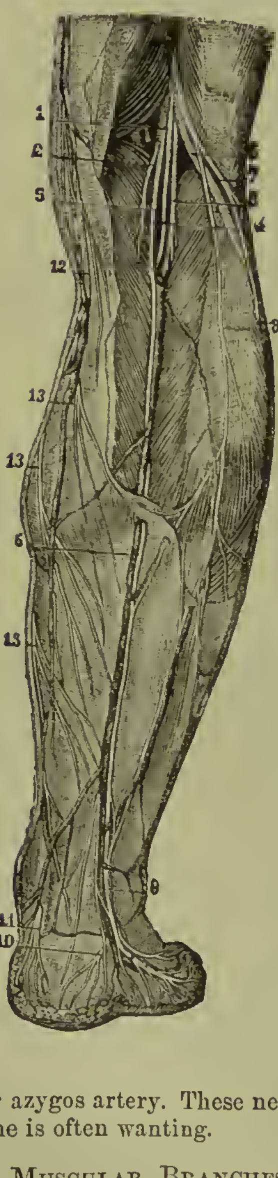


Fig. 447.—Posterior Cutaneous Nerves of the Leg (from Sappey after Hirschfeld and Leveillé).

1, internal popliteal division of the great sciatic nerve; 2, branch to the internal part of the gastrocnemius muscle; 3, 4, branches to the external part and plantaris; 5, communicating branch to the external saphenous nerve; 6, external popliteal nerve; 7, cutaneous branch; 8, communicating branch descending to unite with that from the internal popliteal in, 9, the external saphenous nerve; 10, calcaneal branch from this nerve; 11, calcaneal and plantar cutaneous branches from the posterior tibial nerve; 12, internal saphenous nerve; 13, posterior branches of this nerve.

The inner division of the sciatic nerve, from its commencement to its partition at the foot, is often described in anatomical works under the same appellation throughout; the name varying, however, with different writers, as for example, "cruralis internus," or "popliteus internus,"—Winslow: "tibialis posterior,"—Haller: "tibialis vel tibieus,"—Fischer, &c.

Branches.—The internal popliteal nerve supplies branches to the knee-joint and to the muscles of the calf of the leg, and also part of a cutaneous branch, the external or short saphenous nerve.

Articular Nerves.—The *articular branches* are generally three in number; two of these accompany the upper and lower articular arteries of the inner side of the knee-joint, the third follows the middle or azygos artery. These nerves pierce the ligamentous tissue of the joint.—The upper one is often wanting.

Muscular Branches.—The muscular branches of the internal popliteal nerve arise behind the knee-joint, while the nerve is between the heads of the gastrocnemius muscle :—

a. The nerves to the *gastrocnemius* consist of two branches, which separate one to supply each part of the muscle.

b. The small nerve of the *plantaris* muscle is derived from the outer of the branches just described, or directly from the main trunk (internal popliteal).

c. The *soleus* receives a branch of considerable size, which enters the muscle on the posterior aspect after descending to it in front of the gastrocnemius.

d. The *nerve* of the *popliteus* muscle lies deeper than the preceding branches, and arises somewhat below the joint: it descends along the outer side of the popliteal vessels, and, after turning beneath the lower border of the muscle, enters the deep or anterior surface.

EXTERNAL OR SHORT SAPHENOUS NERVE.

The cutaneous branch of the internal popliteal nerve (ramus communicans tibialis) descends along the leg beneath the fascia, resting on the gastrocnemius, in the furrow between the heads of the muscle, to about midway between the knee and the foot. Here it perforates the fascia, and a little lower down is usually joined by a branch from the external popliteal nerve (communicans peronei). After receiving this communicating branch, the external saphenous nerve descends beneath the integument near the outer side of the tendo Achillis in company with the short saphenous vein, and turns forwards beneath the outer malleolus to end in the skin at the side of the foot and on the little toe. On the dorsum of the foot this nerve communicates with the musculo-cutaneous nerve.

In many cases, the external saphenous nerve supplies the outer side of the fourth toe, as well as the little toe. The union between the saphenous nerve and the branch of the external popliteal nerve occurs in some cases higher than usual, occasionally even at or close to the popliteal space. It sometimes happens that the communication between the nerves is altogether wanting; in which case the cutaneous nerve to the foot is generally contiuued from the branch of the internal popliteal nerve.

POSTERIOR TIBIAL NERVE.

The internal popliteal nerve receives the name of posterior tibial at the lower margin of the popliteus muscle. It passes down the leg with the posterior tibial artery, lying for a short distance at the inner side of the vessel, and afterwards at the outer side; the artery inclining inwards from its origin while the nerve continues its straight course. In the interval between the inner malleolus and the heel, it divides into the two plantar nerves (internal and external). The posterior tibial nerve, like the accompanying vessels, is covered at first by the muscles of the calf of the leg, afterwards only by the integument and fascia, and it rests upon the deep-seated muscles.

Lateral branches.—The deep muscles on the back of the leg and the integument of the sole of the foot receive branches from the posterior tibial nerve in its course along the leg.

a. The *muscular branches* emanate from the upper part of the nerve, either separately or by a common trunk; and one is distributed to each of the deep muscles, viz., the tibialis posticus, the long flexor of the toes, and the long flexor of the great toe. The branch which supplies the last-named muscle runs along the peroneal artery before penetrating the muscle.

b. A *calcaneo-plantar cutaneous* branch is furnished from the posterior tibial nerve; the plantar part perforates the internal annular ligament, and ramifies in the integument at the inner side of the sole of the foot, and beneath the heel.

INTERNAL PLANTAR NERVE.

The internal plantar, the larger of the two nerves to the sole of the foot, into which the posterior tibial divides, accompanies the internal or smaller plantar artery, and supplies nerves to both sides of the three inner toes, and to one side of the fourth. From the point at which it separates from the

posterior tibial nerve, it is directed forwards under cover of the first part of the abductor of the great toe, and, passing between that muscle and the short flexor of the toes, it gives off the internal cutaneous branch for the great toe, and divides opposite the middle of the foot into three digital branches. The outermost of these branches communicates with the external plantar nerve.

Branches.—a. Small *muscular* branches are supplied to the abductor pollicis and flexor brevis digitorum.

b. Small *plantar cutaneous* branches perforate the plantar fascia to ramify in the integument of the sole of the foot.

c. The *digital branches* are named numerically from within outwards: the three outer pass from under cover of the plantar fascia near the clefts between the toes. The first or innermost branch continues single, but the other three bifurcate to supply the adjacent sides of two toes. These branches require separate notice.

The *first* digital branch is that destined for the inner side of the great toe; it becomes subcutaneous farther back than the others, and sends off a branch to the *flexor brevis pollicis.*

Fig. 418.

Fig. 448.—Superficial and Deep Distribution of the Plantar Nerves (from Hirschfeld and Leveillé, slightly modified). $\frac{1}{3}$

The flexor communis brevis, the abductor pollicis and abductor minimi digiti, a part of the tendons of the flexor communis longus, together with the lumbricales muscles, have been removed so as to bring into view the transversus and interossei in the middle of the foot.

a, upon the posterior extremity of the flexor communis brevis, near which, descending over the heel, are seen ramifications of the calcaneal branch of the posterior tibial nerve; *b*, abductor pollicis; *c*, tendon of the flexor communis longus divided close to the place where it is joined by the flexor accessorius; *d*, abductor minimi digiti; *e*, tendon of the flexor longus pollicis between the two portions of the flexor brevis pollicis; 1, internal plantar nerve giving some twigs to the abductor pollicis, and 1′, a branch to the flexor communis brevis, cut as it lies on the accessorius; 2, inner branch of the internal plantar nerve giving branches to the abductor pollicis, flexor brevis pollicis, and forming, 2′, the internal cutaneous of the great toe; 3, continuation of the internal plantar nerve, dividing subsequently into three branches, which form, 3′, 3′, 3′, the collateral plantar cutaneous nerves of the first and second, second and third, and third and fourth toes; 4, the external plantar nerve; 4′, its branch to the abductor minimi digiti; 5, twig of union between the plantar nerves; 6, superficial branch of the external plantar nerve; subsequently dividing into 6′, 6′, the collateral cutaneous nerves of the fourth and fifth toes and the external nerve of the fifth; 7, deep branch of the external plantar nerve giving twigs to the adductor pollicis, the interossei, the transversalis, and to the third and fourth lumbricales muscles.

The *second* branch having reached the interval between the first and second metatarsal bones, furnishes a small twig to the *first lumbricalis* muscle, and bifurcates behind the cleft between the great toe and the second to supply their contiguous sides.

The *third* digital branch, corresponding with the second interosseous space, gives a slender filament to the *second lumbricalis* muscle, and divides in a manner similar

to that of the second branch into two offsets for the sides of the second and third toes.

The *fourth* digital branch. distributed to the adjacent sides of the third and fourth toes, receives a communicating branch from the external plantar nerve.

Along the sides of the toes, cutaneous and articular filaments are given from these digital nerves; and, opposite the ungual phalanx, each sends a dorsal branch to the pulp beneath the nail, and then runs on to the ball of the toe, where it is distributed like the nerves of the fingers.

EXTERNAL PLANTAR NERVE.

The external plantar nerve completes the supply of digital nerves to the toes, furnishing branches to the little toe and half the fourth: it also gives a deep branch of considerable size, which is distributed to several of the short muscles in the sole of the foot. There is thus a great resemblance between the distribution of this nerve in the foot and that of the ulnar nerve in the hand.

The external plantar nerve runs obliquely forwards towards the outer side of the foot, along with the external plantar artery, between the flexor brevis digitorum and the flexor accessorius, as far as the interval between the former muscle and the abductor of the little toe. Here it divides into a superficial and a deep branch, having previously furnished offsets to the *flexor accessorius* and the *abductor minimi digiti.*

a. The *superficial portion* separates into two digital branches, which have the same general arrangement as the digital branches of the internal plantar nerve. They are distributed thus:—

Digital branches.—One of the digital branches continues undivided, and runs along the outer side of the little toe: it is smaller than the other, and pierces the plantar fascia further back. The *short flexor muscle of the little toe,* and occasionally *one or two interosseous* muscles of the fourth metatarsal space receive branches from this nerve.

The larger digital branch communicates with an offset from the internal plantar nerve, and bifurcates near the cleft between the fourth and fifth toes to supply one side of each.

b. The *deep* or *muscular* branch of the external plantar nerve dips into the sole of the foot with the external plantar artery, under cover of the tendons of the flexor muscles and the adductor pollicis, and terminates in numerous branches for the following muscles:—all the interossei (dorsal and plantar) except occasionally one or both of those in the fourth space, the two outer lumbricales, the adductor pollicis, and the transversalis pedis.

Summary of the internal popliteal nerve.—This nerve supplies all the muscles of the back of the leg and sole of the foot, and the integument of the plantar aspect of the toes, the sole of the foot, and in part that of the leg.

EXTERNAL POPLITEAL OR PERONEAL NERVE.

This nerve descends obliquely along the outer side of the popliteal space, lying close to the biceps muscle. Continuing downwards over the outer part of the gastrocnemius muscle (between it and the biceps) below the head of the fibula, the nerve turns round that bone, passing between it and the peroneus longus muscle, and then divides into the *anterior tibial* and the *musculo-cutaneous* nerves.

Lateral branches.—Some articular and cutaneous branches are derived from the external popliteal nerve before its final division.

ARTICULAR NERVES.—The articular branches are conducted to the outer side of the capsular ligament of the knee-joint by the upper and lower

articular arteries of that side. They sometimes arise together, and the upper one occasionally springs from the great sciatic nerve before the bifurcation.

From the place of division of the external popliteal nerve, a *recurrent articular* nerve ascends through the tibialis anticus muscle with the recurrent artery to reach the fore part of the knee-joint.

Fig. 449.

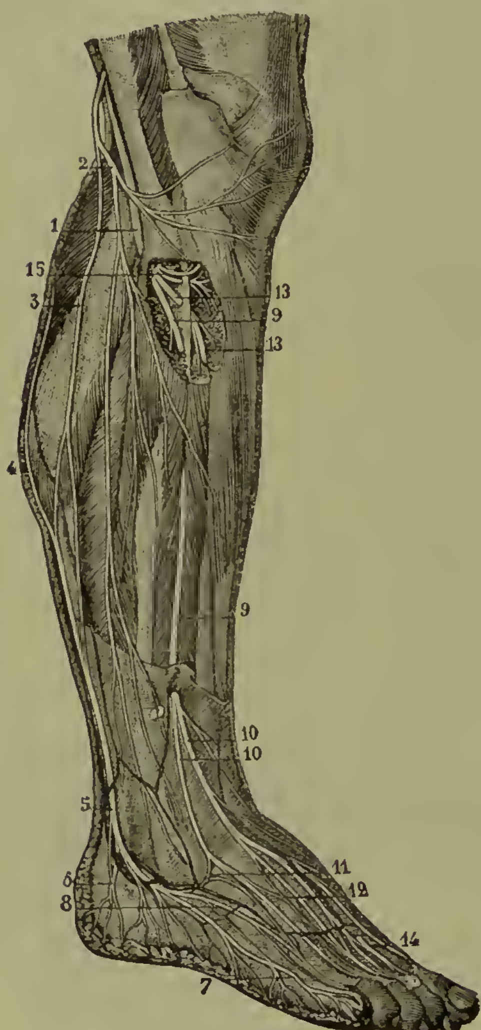


Fig. 449.—Cutaneous Nerves of the Outer Side of the Leg and Foot (from Sappey after Hirschfeld and Leveillé). $\frac{1}{3}$

1, external popliteal nerve; 2, its external cutaneous branch; 3, communicating branch which unites with 4, that from the internal popliteal in 5, the external saphenous nerve; 6, calcaneal branch of the external saphenous; 7, external dorsal digital branch to the fifth toe; 8, collateral dorsal digital branch of the fourth and fifth toes; 9, musculo-cutaneous nerve; 10, its cutaneous branches; 11, loop of union with the external saphenous; 12, union between its outer and inner branches; 13, anterior tibial nerve, shown by the removal of a part of the muscles, and giving muscular branches superiorly; 14, its terminal branch emerging in the space between the first and second toes, where it gives the collateral dorsal digital branches to their adjacent sides.

Cutaneous Nerves.—The cutaneous branches, two or three in number, supply the skin on the back part and outer side of the leg.

The *peroneal communicating branch* (r. communicans fibularis), which joins the short saphenous nerve below the middle of the back of the leg, is the largest of these nerves. In some instances, it continues a separate branch and its cutaneous filaments reach down to the heel or on to the outside of the foot.

Another cutaneous branch extends along the outer side of the leg to the middle or lower part, sending offsets both backwards and forwards.

MUSCULO-CUTANEOUS NERVE.

The musculo-cutaneous (peroneal) nerve descends between the peronei muscles and the long extensor of the toes, and reaches the surface by perforating the fascia in the lower part of the leg on the anterior aspect. It then divides into two branches, distinguished as external and internal, which proceed to the toes. The two branches sometimes perforate the fascia at a different height.

(*a*) *Muscular branches* are given to the peroneus longus and peroneus brevis.

(*b*) *Cutaneous branches* given off before the final division are distributed to the lower part of the leg.

(*c*) The *internal branch* of the musculo-cutaneous nerve, passing forwards along the dorsum of the foot, furnishes one branch to the inner side of the great toe, and others to the contiguous sides of the second and third toes. It gives other offsets, which extend over the inner ankle and side of the foot. This nerve communicates with the long saphenous nerve on the inner side of the foot, and with the anterior tibial nerve between the first and second toes.

Fig. 450.

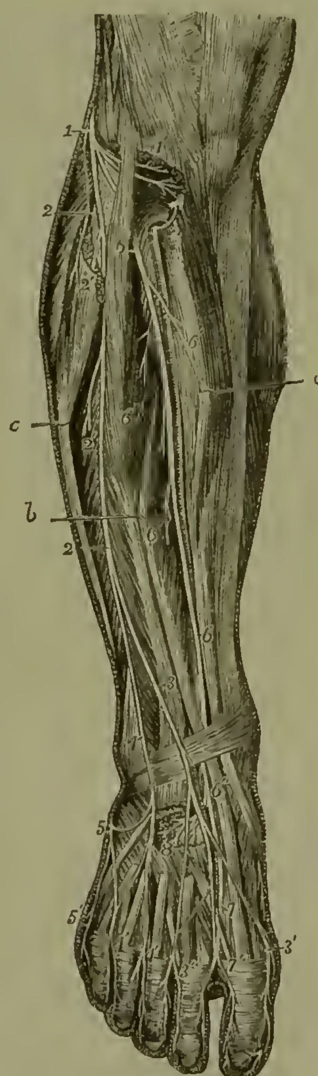


Fig. 450. — View of the Distribution of the Branches of the External Popliteal Nerve in the Front of the Leg and Dorsum of the Foot (from Hirschfeld and Leveillé). $\frac{1}{5}$

The upper part of the peroneus longus muscle has been removed, the tibialis anticus, the long extensor of the great toe and the peroneus longus have been drawn separate in the leg by hooks marked *a*, *b*, and *c*, and the tendons of the extensor muscles, have been removed in the dorsum of the foot, to show the deeper seated nerves; 1, the external popliteal or peroneal nerve winding round the upper part of the fibula; 1′, its recurrent articular branches exposed by the dissection of the upper part of the tibialis anticus muscle; 2, 2, the musculo-cutaneous nerve; 2′, 2′, twigs to the long and short peroneal muscles; 3, internal branch of the musculo-cutaneous nerve; 3′, 3′, its dorsal digital branches to the inside of the great toe, and to the adjacent sides of the second and third toes; 4, the external branch; 4′, 4′, its dorsal digital branches to the adjacent sides of the third and fourth toes, and in part to the space between the fourth and fifth toes; 5, the external saphenous nerve descending on the outer border of the foot, and uniting at two places with the outer branch of the musculo-cutaneous; 5′, its branch to the outer side of the fifth toe; 6, placed on the upper part of the extensor communis digitorum, marks the anterior tibial nerve passing beneath the muscles; 6, placed farther down on the tendon of the tibialis anticus, points to the nerve as it crosses to the inside of the anterior tibial artery; 6′, its muscular branches in the leg; 6″, on the tendon of the extensor longus pollicis points to the anterior tibial nerve after it has passed into the foot behind that tendon; 7, its inner branch uniting with a twig of the musculo-cutaneous, and giving the dorsal digital nerves to the adjacent sides of the first and second toes; 8, distribution of its outer branch to the extensor brevis digitorum and tarsal articulations.

(*d*) The *external branch*, larger than the internal one, descends over the foot towards the fourth toe, which, together with the contiguous borders of the third and fifth toes, it supplies with branches. Cutaneous nerves, derived from this branch, spread over the outer ankle and the outer side of the foot, where they are connected with the short saphenous nerve.

The dorsal digital nerves are continued on to the last phalanges of the toes.

The number of toes supplied by each of the two divisions of the musculo-cutaneous nerve is liable to vary; together these nerves commonly supply all the toes on the dorsal aspect, excepting the outer side of the little toe, which receives a branch from the short saphenous nerve, and the adjacent sides of the great toe and the second toe, to which the anterior tibial nerve is distributed: with this latter branch, however, it generally communicates.

ANTERIOR TIBIAL NERVE.

The anterior tibial (interosseous nerve), commencing between the fibula and the peroneus longus, inclines obliquely beneath the long extensor of the toes to the fore part of tho interosseous membrane, and there comes into contact with the anterior tibial vessels, and with those vessels it descends to the front of the ankle joint, where it divides into an external and an internal branch. The nerve first reaches the outer side of the anterior tibial artery, above the middle of the leg; and, after crossing in front of that vessel once or oftener, lies to the inner side of it at the bend of the ankle.

(*a*) *Muscular branches.*—In its course along the leg, the anterior tibial nerve gives slender filaments to the muscles between which it is placed, namely, the tibialis anticus, the long extensor of the toes, and the special extensor of the great toe.

(*b*) The *external branch* of the anterior tibial nerve, turns outwards over the tarsus beneath the short extensor of the toes; and, having become enlarged (like the posterior interosseous nerve on the wrist) terminates in branches which supply the short extensor muscle, and likewise the articulations of the foot.

(*c*) The *internal branch,* continuing onwards in the direction of the anterior tibial nerve, accompanies the dorsal artery of the foot to the first interosseous space, and ends in two branches, which supply the integument on the neighbouring sides of the great toe and the second toe on their dorsal aspect. It communicates with the internal division of the musculo-cutaneous nerve.

Summary of the external popliteal nerve.—This nerve supplies, besides articular branches to the knee, ankle, and foot, the peronei muscles, extensor muscles of the foot, also the integument of the front of the leg and dorsum of the foot. It gives the ramus communicans fibularis to the short saphenous branch of the internal popliteal nerve, and communicates with the long saphenous nerve.

SYNOPSIS OF THE CUTANEOUS DISTRIBUTION OF THE CEREBRO-SPINAL NERVES.

Head.—The *face and head in front of the ear* are supplied with sensory nerves from the fifth cranial nerve. The ophthalmic division supplies branches to the forehead, upper eyelid, and dorsum of the nose. The superior maxillary division supplies the cheek, ala of the nose, upper lip, lower eyelid, and the region behind the eye, over the temporal fascia. The inferior maxillary division supplies the chin and lower lip, the pinna of the ear on its outer side, and the integument in front of the ear and upwards to the vertex of the head.

The *head, behind the ear,* is mainly supplied by the great occipital branch of the posterior division of the second spinal nerve, but above the occipital protuberance there is also distributed the branch from the posterior division of the third spinal nerve; and, in front of the area of the great occipital nerve, is a space supplied by anterior divisions of spinal nerves, viz., the back of the pinna of the ear, together with the integument behind and that in front over the parotid gland, which are supplied by the great auricular nerve; while between the area of that nerve and the great occipital the small occipital nerve intervenes. The auricular branch of the pneumo-gastric nerve also is distributed on the back of the ear.

Trunk.—The *posterior divisions of the spinal nerves* supply an area, extending on the back from the vertex of the skull to the buttock. This area is narrow in the neck; it is spread out over tho back of the scapula;

and on the buttock the distribution of the lumbar nerves extends to the trochanters.

The *area supplied by the cervical plexus*, besides extending upwards, as already mentioned, on the lateral part of the skull, stretches over the front and sides of the neck, and the upper part of the shoulder and breast.

The *area of the anterior divisions of the dorsal and first lumbar nerves* meets superiorly with that of the cervical plexus, and posteriorly with that of the posterior divisions of dorsal and lumbar nerves. It passes down over the haunch and along by the outer part of Poupart's ligament, and includes part of the scrotum and a small portion of the integument of the thigh internal to the saphenous opening.

The *perinæum* and *penis* are supplied by the pudic nerve ; the *scrotum* by branches of the pudic, inferior pudendal, and ilio-inguinal nerves.

Upper Limb.—The *shoulder*, supplied superiorly by the cervical plexus, receives its cutaneous nerves inferiorly as far as the insertion of the deltoid from the circumflex nerve.

The *arm* internally is supplied by the intercosto-humeral nerve and the nerve of Wrisberg. The inner and anterior part is supplied by the internal cutaneous nerve ; and the posterior and outer part by the internal and external branches of the musculo-spiral nerve.

The *forearm*, anteriorly and on the outer side, is supplied by the external cutaneous ; on its outer and posterior aspect, superiorly by the external cutaneous branches of the musculo-spiral, and inferiorly by the radial branch of the same nerve. On the inner side, both in front and behind, is the internal cutaneous nerve, and inferiorly are branches of the ulnar.

On the back of the hand are the radial and ulnar nerves, the radial supplying about three fingers and a half or less, and the ulnar one and a half or more.

On the front of the hand, the median nerve supplies three fingers and a half, and the ulnar one and a half. In the *palm* is a branch of the median given off above the wrist. On the *ball of the thumb* are branches of the musculo-cutaneous, median, and radial nerves.

Lower Limb.—The *buttock* is supplied from above by the cutaneous branches of the posterior divisions of the lumbar nerves with the ilio-hypogastric and lateral branches of the last dorsal nerves ; internally by the posterior divisions of the sacral nerves ; externally by the posterior branch of the external cutaneous nerve proceeding from the front ; and inferiorly by branches of the small sciatic nerve proceeding from below.

The *thigh* is supplied externally by the external cutaneous nerve ; posteriorly, and in the upper half of its inner aspect, by the small sciatic ; anteriorly, and in the lower half of the inner aspect, by the middle and internal cutaneous.

The *leg* is supplied posteriorly by the small sciatic and short saphenous nerves ; internally by the long saphenous and branches of the internal cutaneous of the thigh ; and outside and in front by cutaneous branches of the external popliteal nerve, and by its musculo-cutaneous branch.

On the dorsum of the foot are the branches of the musculo-cutaneous, supplying all the toes with the exception of the adjacent sides of the first and second, which are supplied by the anterior tibial, and the outer side of the little toe, which, with the outer side of the foot, is supplied by the short saphenous nerve. The long saphenous is the cutaneous nerve on the inner side of the foot.

The *sole of the foot* is supplied by the plantar nerves. The internal plantar nerve gives branches to three toes and a half; the external to the remaining one toe and a half.

SYNOPSIS OF THE MUSCULAR DISTRIBUTION OF THE CEREBRO-SPINAL NERVES.

MUSCLES OF THE HEAD AND FORE PART OF THE NECK.

The *muscles of the orbit* are mostly supplied by the third cranial nerve—the superior division of that nerve being distributed to the levator palpebræ and the superior rectus muscles; and the inferior division to the inferior and internal recti and the inferior oblique. The superior oblique muscle is supplied by the fourth nerve, the external rectus by the sixth; while the tensor tarsi has no special nerve apart from those of the orbicularis palpebrarum, which are derived from the facial.

The *superficial muscles of the face and scalp*, which are associated in their action as a group of muscles of expression, are supplied by the portio dura of the seventh cranial nerve; the retrahens auriculam and occipitalis muscles being supplied by the posterior auricular branch.

The *deep muscles of the face*, employed in mastication, viz., the temporal, masseter, buccinator and two pterygoid muscles, are supplied by the inferior maxillary division of the fifth cranial nerve.

Muscles above the hyoid bone.—The mylo-hyoid muscle and anterior belly of the digastric are supplied by a special branch of the inferior maxillary division of the fifth cranial nerve; the posterior belly of the digastric muscle, and the stylo-hyoid, are supplied by branches of the portio dura. The genio-hyoid and the muscles of the tongue receive their nervous supply from the hypoglossal nerve.

The *muscles ascending to the hyoid bone and larynx*, viz., the sterno-hyoid, omo-hyoid, and sterno-thyroid, are supplied from the ramus descendens noni and its loop with the cervical plexus, while the thyro-hyoid muscle receives a separate twig from the ninth nerve.

The larynx, pharynx, and soft palate.—The crico-thyroid muscle is supplied by the external laryngeal branch of the pneumo-gastric nerve, and the other intrinsic muscles of the larynx by the recurrent laryngeal. The muscles of the pharynx are supplied principally by the pharyngeal branch of the pneumo-gastric; the stylo-pharyngeus, however, is supplied by the glosso-pharyngeal nerve. Of the muscles of the soft palate unconnected with the tongue or pharynx, the tensor palati receives its nerve from the otic ganglion (which also supplies the tensor tympani); the levator palati gets a twig (Meckel) from the posterior palatine branch of the spheno-palatine ganglion, and the azygos uvulæ is probably supplied from the same source.

MUSCLES BELONGING EXCLUSIVELY TO THE TRUNK, AND MUSCLES ASCENDING TO THE SKULL.

All those *muscles of the back* which are unconnected with the upper limb, viz., the posterior serrati, the splenius, complexus, erector spinæ, and the muscles more deeply placed, receive their supply from the posterior divisions of the spinal nerves.

The *sterno-mastoid* is supplied by the spinal accessory nerve and a twig of the cervical plexus coming from the second cervical nerve.

The *rectus capitis anticus major and minor* are supplied by twigs from the upper cervical nerves; the *longus colli* and *scaleni* muscles by twigs from the lower cervical nerves.

The *muscles of the chest*, viz., the intercostals, subcostals, levatores costarum, and triangularis sterni, are supplied by the intercostal nerves.

The *obliqui, transversus*, and *rectus* of the abdomen are supplied by the lower intercostal nerves; and the oblique and transverse muscles also get branches from the ilio-inguinal and ilio-hypogastric nerves. The *cremaster* muscle is supplied by the genital branch of the genito-crural nerve.

The *quadratus lumborum* (like the psoas) receives small branches from the lumbar nerves before they form the plexus.

The *diaphragm* receives the phrenic nerves from the fourth and fifth cervical nerves, and likewise sympathetic filaments from the plexuses round the phrenic arteries.

The *muscles of the urethra and penis* are supplied by the pudic nerve; the *levator and sphincter ani* by the pudic and by the fourth and fifth sacral and the coccygeal nerves; and the *coccygeus* muscle by the three last named nerves.

MUSCLES ATTACHING THE UPPER LIMB TO THE TRUNK.

The *trapezius* and the *sterno-cleido-mastoid* receive the distribution of the *spinal accessory* nerve, and, in union with it, filaments from the cervical plexus.

The *latissimus dorsi* receives the long subscapular nerve.

The *rhomboidei* are supplied by a special branch from the anterior division of the fifth cervical nerve.

The *levator anguli scapulæ* is supplied by branches from the anterior division of the third cervical nerve, and sometimes partly also by the branch to the rhomboid muscles.

The *serratus magnus* has a special nerve, the posterior thoracic, derived from the fifth and sixth cervical nerves.

The *subclavius* receives a special branch from the place of union of the fifth and sixth cervical nerves.

The *pectorales* are supplied by the anterior thoracic branches of the brachial plexus, the larger muscle receiving filaments from both these nerves, and the smaller from the inner only.

MUSCLES OF THE UPPER LIMB.

Muscles of the shoulder.—The supraspinatus and infraspinatus are supplied by the supra scapular nerve; the subscapularis by the two smaller subscapular nerves; the teres major by the second subscapular, and the deltoid and teres minor by the circumflex nerve.

Posterior muscles of the arm and forearm.—The triceps, anconeus, supinator longus, and extensor carpi radialis longior are supplied by direct branches of the musculo-spiral nerve; while the extensor carpi radialis brevior and the other extensor muscles in the forearm receive their branches from the posterior interosseous division of that nerve.

Anterior muscles of the arm and forearm.—The coraco-brachialis, biceps, and brachialis anticus are supplied by the musculo-cutaneous nerve: the brachialis anticus likewise generally receives a twig from the musculo-spiral nerve. The muscles in front of the forearm are supplied by the median nerve, with the exception of the flexor carpi ulnaris and the ulnar half of the flexor profundus digitorum, which are supplied by the

ulnar nerve, and the supinator longus, which is supplied by the musculo-spiral.

Muscles of the hand.—The abductor and opponens pollicis, the outer half of the flexor brevis pollicis, and the two outer lumbricales muscles, are supplied by the median nerve: all the other muscles receive their nerves from the ulnar.

MUSCLES OF THE LOWER LIMB.

Posterior muscles of the hip and thigh.—The gluteus maximus is mainly supplied by the small sciatic nerve, and receives at its upper part a separate branch from the sacral plexus. The gluteus medius and minimus, together with the tensor vaginæ femoris, are supplied by the gluteal nerve. The pyriformis, gemelli, obturator internus, and quadratus femoris receive special branches from the sacral plexus. The hamstring muscles are supplied by branches from the great sciatic nerve.

Anterior and internal muscles of the thigh.—The psoas muscle is supplied by separate twigs from the lumbar nerves. The iliacus, quadriceps extensor femoris, and sartorius are supplied by the anterior crural nerve. The adductor muscles, the obturator externus and the pectineus, are supplied by the obturator nerve, but the adductor magnus likewise receives a branch from the great sciatic, and the pectineus sometimes has a branch from the anterior crural.

Anterior muscles of the leg and foot.—The muscles in front of the leg, together with the extensor brevis digitorum, are supplied by the anterior tibial nerve.

The *peroneus longus* and *brevis* are supplied by the musculo-cutaneous nerve.

Posterior muscles of the leg.—The gastrocnemius, plantaris, soleus, and popliteus are supplied by branches from the internal popliteal nerve; the deep muscles, viz., the flexor longus digitorum, flexor longus pollicis, and tibialis posticus, derive their nerves from the posterior tibial.

Plantar muscles.—The flexor brevis digitorum, the abductor and flexor brevis pollicis, and the two inner lumbricales, are supplied by the internal plantar nerve; all the others, including the flexor accessorius and interossei, are supplied by the *external plantar nerve.*

III. SYMPATHETIC NERVES.

The nerves of the sympathetic system (nervus intercostalis; nerves of organic life—Bichat) are distributed in general to all the internal viscera, but some organs receive their nerves also from the cerebro-spinal system, as the lungs, the heart, and the upper and lower parts of the alimentary canal. It appears from physiological researches to be also the special province of the sympathetic system to supply nerves to the coats of the blood-vessels.

This division of the nervous system consists of a somewhat complicated collection of ganglia, cords and plexuses, the parts of which may, for convenience, be classified in three groups, viz., the principal gangliated cords, the great prevertebral plexuses with the nerves proceeding from them, and the ganglia of union with cranial nerves.

The *gangliated cords* consist of two series, in each of which the ganglia are connected by intervening cords. These cords are placed symmetrically in

front of the vertebral column, and extend from the base of the skull to the coccyx. Superiorly they are connected with plexuses which enter the cranial cavity, while inferiorly they converge on the sacrum, and terminate in a single ganglion on the coccyx. The several portions of the cords are distinguished as cervical, dorsal, lumbar, and sacral, and in each of these parts the ganglia are equal in number, or nearly so, to the vertebræ on which they lie, except in the neck, where there are only three.

Fig. 451.

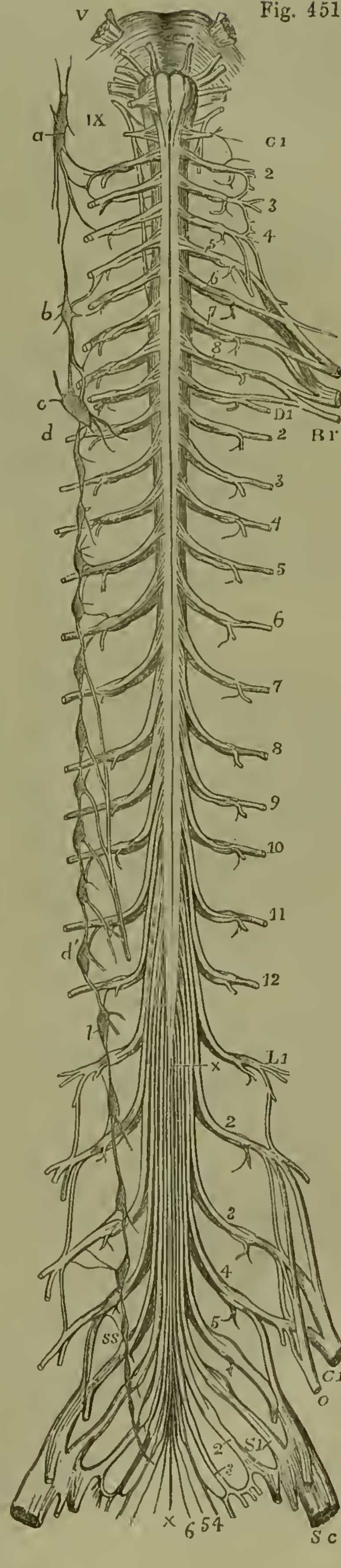


Fig. 451.—Diagrammatic Outline of the Sympathetic Cord of one side in connection with the Spinal Nerves.

The full description of this figure will be found at p. 629.

On the right side the following letters indicate parts of the sympathetic nerves; viz., *a*, the superior cervical ganglion, communicating with the upper cervical spinal nerves and continued below into the great sympathetic cord; *b*, the middle cervical ganglion; *c*, *d*, the lower cervical ganglion united with the first dorsal; *d'*, the eleventh dorsal ganglion; from the fifth to the ninth dorsal ganglia the origins of the great splanchnic nerve are shown; *l*, the lowest dorsal or upper lumbar ganglion; *ss*, the upper sacral ganglion. In the whole extent of the sympathetic cord, the twigs of union with the spinal nerves are shown.

Connection of the gangliated cords with the cerebro-spinal system.—The ganglia are severally connected with the spinal nerves in their neighbourhood by means of short cords; each connecting cord consisting of a white and a grey portion, the former of which may be considered as proceeding from the spinal nerve to the ganglion, the latter from the ganglion to the spinal nerve. At its upper end the gangliated cord communicates likewise with certain cranial nerves. The main cords intervening between the ganglia, like the smaller ones connecting the ganglia with the spinal nerves, are composed of a grey and white part, the white being continuous with the fibres of the spinal nerves prolonged to the ganglia.

The *great prevertebral plexuses* comprise three large aggregations of nerves, or nerves and ganglia situated in front of the spine, and occupying respectively the thorax, the abdomen, and the pelvis. They are single and median, and are

named respectively the cardiac, the solar, and the hypogastric plexus. These plexuses receive branches from both the gangliated cords above noticed, and they constitute centres from which the viscera are supplied with nerves.

The *cranial ganglia of the sympathetic* are the ophthalmic, spheno-palatine, submaxillary, and otic, which, being intimately united with the fifth cranial nerve, have already been described along with that nerve. They are also more or less directly connected with the upper end of the sympathetic gangliated cords; but it will be unnecessary to give any special description of them in this place.

A. THE GANGLIATED CORDS.

THE CERVICAL PART.

In the neck, each gangliated cord is deeply placed behind the sheath of the great cervical blood-vessels, and in contact with the muscles which immediately cover the fore part of the vertebral column. It comprises three ganglia, the first of which is placed near the base of the skull, the second in the lower part of the neck, and the third immediately above the head of the first rib.

THE UPPER CERVICAL GANGLION.

This is the largest ganglion of the great sympathetic cord. It is continued superiorly into an ascending branch, and tapers below into the connecting cord, so as to present usually a fusiform shape; but there is considerable variety in this respect in different cases, the ganglion being occasionally broader than usual, and sometimes constricted at intervals. It has the reddish-grey colour characteristic of the ganglia of the sympathetic system. It is placed on the larger rectus muscle, opposite the second and third cervical vertebræ, and behind the internal carotid artery.

Connection with spinal nerves.—At its outer side the superior cervical ganglion is connected with the first four spinal nerves, by means of slender cords, which have the structure pointed out in the general description as being common to the series.

The circumstance of this ganglion being connected with so many as four spinal nerves, together with its occasionally constricted appearance, is favourable to the view that it may be regarded as consisting of several ganglia which have coalesced.

Connection with cranial nerves.—Small twigs connect the ganglion or its cranial cord with the second ganglion of the pneumo-gastric, and with the ninth cranial nerve, near the base of the skull; and another branch, which is directed upwards from the ganglion, divides at the base of the skull into two filaments, one of which ends in the second (petrosal) ganglion of the glosso-pharyngeal nerve; while the other, entering the jugular foramen, joins the ganglion of the root of the pneumo-gastric.

Besides the branches connecting it with cranial and spinal nerves, the first cervical ganglion gives off also the ascending branch, the upper cardiac nerve, pharyngeal nerves, and branches to blood-vessels.

1. ASCENDING BRANCH AND CRANIAL PLEXUSES.

The ascending branch of the first cervical ganglion is soft in texture and of

a reddish tint, seeming to be in some degree a prolongation of the ganglion itself. In its course to the skull, it is concealed by the internal carotid artery, with which it enters the carotid canal in the temporal bone, and it is then divided into two parts, which are placed one on the outer, the other on the inner side of the vessel.

Fig. 452.

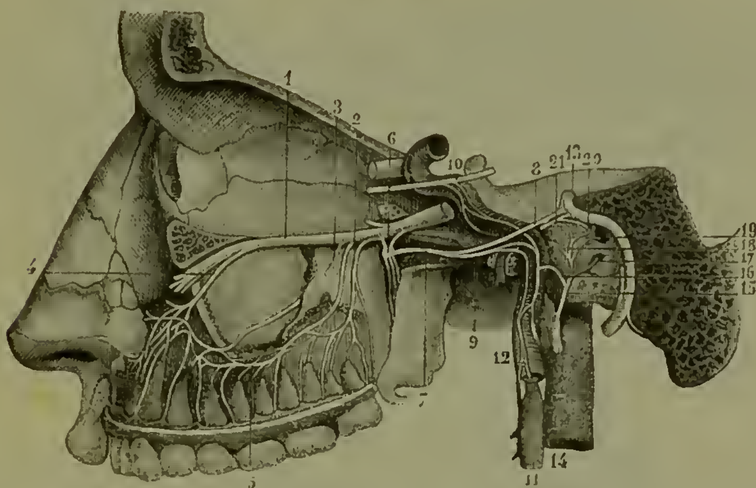


Fig. 452.—Connections of the Sympathetic Nerve through its Carotid Branch with some of the Cranial Nerves.

The full description of this figure will be found at p. 602. The following numbers refer to sympathetic nerves and their connections :—6, spheno-palatine ganglion ; 7, Vidian nerve ; 9, its carotid branch ; 10, a part of the sixth nerve, receiving twigs from the carotid plexus of the sympathetic ; 11, superior cervical sympathetic ganglion ; 12, its prolongation in the carotid branch ; 15, anastomosing nerve of Jacobson ; 16, twig uniting it to the sympathetic.

The *external division* distributes filaments to the internal carotid artery, and, after communicating by means of other filaments with the internal division of the cord, forms the *carotid plexus.*

The *inner division,* rather the smaller of the two, supplies filaments to the carotid artery, and goes to form the *cavernous plexus.* The terminal parts of these divisions of the cranial cord are prolonged on the trunk of the internal carotid, and extend to the cerebral and ophthalmic arteries, around which they form secondary plexuses, those on the cerebral artery ascending to the pia mater. One minute plexus enters the eye-ball with the central artery of the retina.

It was stated by Ribes (Mem. de la Société Méd. d'Emulation, tom. viii. p. 606,) that the cranial prolongations of the sympathetic nerve from the two sides coalesce with one another on the anterior communicating artery,—a small ganglion or a plexus being formed at the point of junction; but this connection has not been satisfactorily made out by other observers.

Carotid Plexus.—The carotid plexus, situated on the outer side of the internal carotid artery at its second bend (reckoning from below), or between the second and third bends, joins the fifth and sixth cranial nerves, and gives many filaments to the vessel on which it lies.

Branches.—(*a*) The connection with the *sixth nerve* is established by means of one or two filaments of considerable size, which are supplied to that nerve where it lies by the side of the internal carotid artery.

(*b*) The filaments connected with the *Gasserian ganglion* of the fifth nerve proceed sometimes from the carotid plexus, at others from the cavernous.

(*c*) The *deep branch* of the Vidian nerve passes backwards to the carotid plexus, and after leaving the Vidian canal, lies in the cartilaginous substance which closes the foramen lacerum medium. Valentin describes nerves as furnished to the dura mater from the carotid plexus.

Cavernous Plexus.—The cavernous plexus, named from its position in the sinus of the same name, is placed below and rather to the inner side of the highest turn of the internal carotid artery. Besides giving branches on the artery, it communicates with the third, the fourth and the ophthalmic of the fifth cranial nerves.

Branches.—(*a*) The filament which joins the *third nerve* comes into connection with it close to the point of division of that nerve.

(*b*) The branch to the *fourth nerve*, which may be derived from either the cavernous or the carotid plexus, joins the nerve where it lies in the wall of the cavernous sinus.

(*c*) The filaments connected with the *ophthalmic trunk* of the *fifth* nerve are supplied to its inner surface. One of them is continued forwards to the lenticular ganglion, either in connection with or distinct from the nasal nerve.

2. PHARYNGEAL NERVES AND PLEXUS.

These nerves arise from the inner part of the ganglion, and are directed obliquely inwards to the side of the pharynx. Opposite the middle constrictor muscle they unite with branches of the pneumo-gastric and glosso-pharyngeal nerves; and by their union with those nerves the *pharyngeal plexus* is formed. Branches emanating from the plexus are distributed to the muscles and mucous membrane of the pharynx.

3. UPPER CARDIAC NERVE.

Each of the cervical ganglia of the sympathetic furnishes a cardiac branch, the three being named respectively the upper, middle and lower cardiac nerves.

These branches are continued singly, or in connection, to the large prevertebral centre (cardiac plexus) of the thorax. Their size varies considerably, and where one branch is smaller than common, another will be found to be increased in size, as if to compensate for the defect. There are some differences in the disposition of the nerves of the right and left sides.

The *upper cardiac nerve* (n. cardiacus superficialis) of the *right side* proceeds from two or more branches of the ganglion, with, in some instances, an offset from the cord connecting the first two ganglia. In its course down the neck the nerve lies behind the carotid sheath, in contact with the longus colli muscle; and it is placed in front of the lower thyroid artery and the recurrent laryngeal nerve. Entering the thorax, it passes in some cases before, in others behind the subclavian artery, and is directed along the innominate artery to the back part of the arch of the aorta, where it ends in the deep cardiac plexus, a few small filaments continuing also to the front of the great vessel. Some branches distributed to the thyroid body accompany the inferior thyroid artery.

In its course downwards the cardiac nerve is repeatedly connected with other branches of the sympathetic, and with the pneumo-gastric nerve. Thus, about the middle of the neck it is joined by some filaments from the external laryngeal

nerve; and, rather lower down, by one or more filaments from the trunk of the pneumo-gastric nerve; lastly, on entering the chest, it joins with the recurrent laryngeal.

Fig. 453.

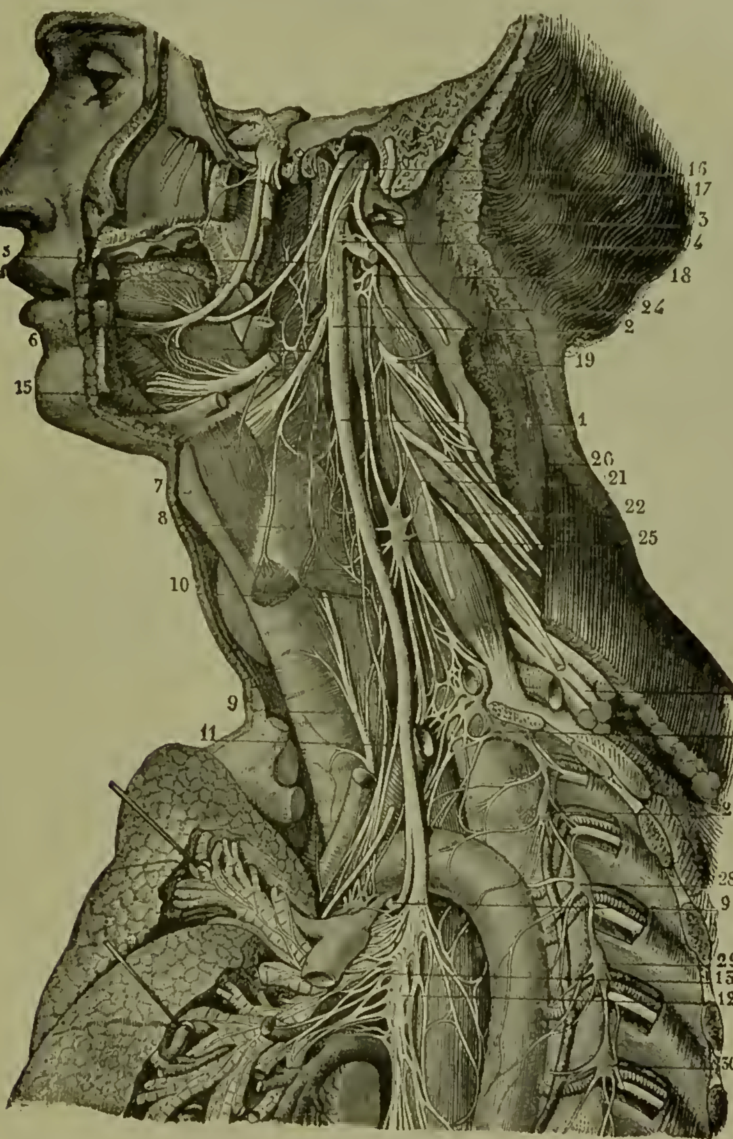


Fig. 453.—Connections of the Cervical and Upper Dorsal Sympathetic Ganglia and Nerves on the Left Side.

The full description of this figure will be found at p. 620. The following numbers refer to the sympathetic ganglia and nerves, and those immediately connected with them:—3, pharyngeal plexus; 8, laryngeal plexus; 13, pulmonary plexus; and to the reader's left, above the pulmonary artery, a part of the cardiac plexus; 24, superior cervical ganglion of the sympathetic; 25, middle cervical ganglion; 26, inferior cervical ganglion united with the first dorsal ganglion; 27, 28, 29, 30, second, third, fourth, and fifth dorsal ganglia.

Variety.—Instead of passing to the thorax in the manner described, the superior cardiac nerve may join the cardiac branch furnished from one of the other cervical ganglia. Scarpa describes this as the common disposition of the nerve; but Cruveilhier (Anat. Descript., t. iv.) states that he has not in any case found the cardiac nerves to correspond exactly with the figures of the "Tabulæ Neurologicæ."

The superficial cardiac nerve of the *left side* has, while in the neck, the same course and connections as that of the right ride. But within the chest it follows the left carotid artery to the arch of the aorta, and ends in some instances in the superficial cardiac plexus, while in others it joins the deep plexus ; and accordingly it passes either in front of or behind the arch of the aorta.

4. BRANCHES TO BLOOD-VESSELS.

The nerves which ramify on the arteries (nervi molles) spring from the front of the ganglion, and twine round the trunk of the carotid artery. They are prolonged on each branch of the external carotid, and form slender plexuses upon them.

Communications with other nerves.—From the plexus on the facial artery is derived the filament which joins the submaxillary ganglion; and, from that on the middle meningeal artery, twigs have been described as extending to the otic ganglion, as well as to the gangliform enlargement of the facial nerve. Lastly, a communication is established between the plexus on the carotid artery and the digastric branch of the facial nerve.

Small *ganglia* are occasionally found on some of the vascular plexuses, close to the origin of the vessels with which they are associated. Thus lingual, temporal, and pharyngeal ganglia have been described ; and besides these there is a larger body, the ganglion intercaroticum, placed on the inner side of the angle of division of the common carotid artery. This body, long known to anatomists as a ganglion, has been stated by Luschka to have a structure very different from the nervous ganglia in general, and has been named by him the "glandula intercarotica."

The *ganglion intercaroticum* was described by Luschka as presenting principally a follicular structure, and regarded by him as being of a nature similar to the glandula coccygea, which he had previously discovered. It appears, however, from the researches of Julius Arnold, that the follicular appearances observed by Luschka, both in this instance and in the coccygeal gland, were produced by arterial glomeruli seen in section ; and that the ganglion intercaroticum consists of numbers of those glomeruli gathered into several larger masses, and of dense plexuses of nerves surrounding respectively the glomeruli, the masses, and the whole structure. Within those plexuses nerve-cells are scattered, but not in very great number. The ganglion is usually about one-fourth of an inch long; but, according to Luschka, may be divided into small separate masses, and thus escape attention, or be supposed to be absent.—(Luschka, Anat. d. Menschen, vol. i. 1862 ; and Julius Arnold, in Virchow's Archiv., June, 1865.)

MIDDLE CERVICAL GANGLION.

The middle ganglion (ganglion thyroideum), much the smallest of the cervical ganglia, is placed on or near the inferior thyroid artery. It is usually connected with the fifth and sixth spinal nerves, but in a somewhat variable manner. It gives off thyroid branches and the middle cardiac nerve.

THYROID BRANCHES.—From the inner side of the ganglion some twigs proceed along the inferior thyroid artery to the thyroid body, where they join the recurrent laryngeal and the external laryngeal nerves. Whilst on the artery these branches communicate with the upper cardiac nerve.

THE MIDDLE CARDIAC NERVE (nervus cardiacus profundus v. magnus) of the *right side* is prolonged to the chest behind the sheath of the common carotid artery, and either in front of or behind the subclavian artery. In the

chest it lies on the trachea, where it is joined by filaments of the recurrent laryngeal nerve, and it ends in the right side of the deep cardiac plexus. While in the neck, the nerve communicates with the upper cardiac nerve and the recurrent branch of the pneumo-gastric.

On the *left side*, the middle cardiac nerve enters the chest between the left carotid and subclavian arteries, and joins the left side of the deep cardiac plexus.

When the middle cervical ganglion is small, the middle cardiac nerve may be found to be an offset of the inter-ganglionic cord.

LOWER CERVICAL GANGLION.

The lower or third cervical ganglion is irregular in shape, usually somewhat flattened and round or semilunar, and is frequently united in part to the first thoracic ganglion. Placed in a hollow between the transverse process of the last cervical vertebra and the neck of the first rib, it is concealed by the vertebral artery. It is connected by short communicating cords with the two lowest cervical nerves. Numerous branches are given off from it, among which the largest is the lower cardiac nerve.

THE LOWER CARDIAC NERVE, issuing from the third cervical ganglion or from the first thoracic, inclines inwards on the *right side*, behind the subclavian artery, and terminates in the cardiac plexus behind the arch of the aorta. It communicates with the middle cardiac and recurrent laryngeal nerves behind the subclavian artery.

On the *left side*, the lower cardiac often becomes blended with the middle cardiac nerve, and the cord resulting from their union terminates in the deep cardiac plexus.

BRANCHES TO BLOOD-VESSELS.—From the lowest cervical and first dorsal ganglia a few slender branches ascend along the vertebral artery in its osseous canal, forming a plexus round the vessel by their inter-communications, and supplying it with offsets. This plexus is connected with the cervical spinal nerves as far upwards as the fourth.

One or two branches frequently pass from the lower cervical ganglion to the first dorsal ganglion in front of the subclavian artery, forming loops round the vessel (ansæ Vieussenii), and supplying it with small offsets.

THORACIC PART OF THE GANGLIATED CORD.

In the thorax the gangliated cord is placed towards the side of the spinal column, in a line passing over the heads of the ribs. It is covered by the pleura, and crosses the intercostal blood-vessels.

Opposite the head of each rib the cord usually presents a ganglion, so that there are commonly twelve of these; but, from the occasional coalescence of two, the number varies slightly. The first ganglion when distinct is larger than the rest, and is of an elongated form; but it is often blended with the lower cervical ganglion. The rest are small, generally oval, but very various in form.

Connection with the spinal nerves.—The branches of connection between the spinal nerves and the ganglia of the sympathetic are usually two in number for each ganglion; one of these generally resembling the spinal nerve in structure, the other more similar to the sympathetic nerve.

BRANCHES OF THE GANGLIA.

The branches furnished by the *first five or six ganglia* are small, and are

Fig. 454.

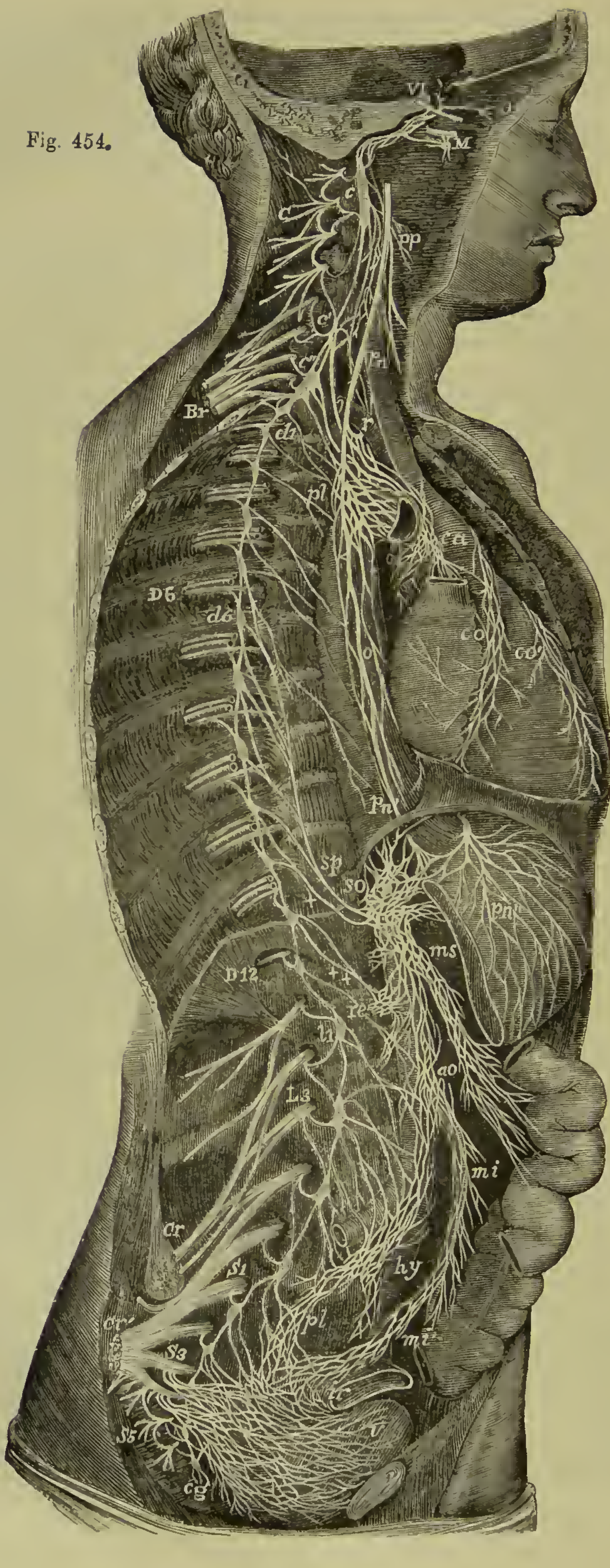

VI
M
pp
Br
d1
pl
ca
D6
d6
co
co'
Pn
Sp
so
pn
ms
D12
re
L1
L3
ao
mi
cr
S1
hy
pl
S3
S5
cg

Fig. 454.—Diagrammatic View of the Sympathetic Cord of the Right Side, showing its Connections with the Principal Cerebro-Spinal Nerves and the Main Preaortic Plexuses. $\frac{1}{4}$

Cerebro-spinal Nerves.—VI, a portion of the sixth cranial nerve as it passes through the cavernous sinus, receiving two twigs from the carotid plexus of the sympathetic nerve; O, ophthalmic ganglion connected by a twig with the carotid plexus; M, connection of the spheno-palatine ganglion by the Vidian nerve with the carotid plexus; C, cervical plexus; Br, brachial plexus; D 6, sixth intercostal nerve; D 12, twelfth; L 3, third lumbar nerve; S 1, first sacral nerve; S 3, third; S 5, fifth; Cr, anterior crural nerve; Cr′, great sciatic, *pn*, pneumo-gastric nerve in the lower part of the neck; *r*, recurrent nerve winding round the subclavian artery.

Sympathetic Cord.—*c*, superior cervical ganglion; *c′*, second or middle; *c″*, inferior: from each of these ganglia cardiac nerves (all deep on this side) are seen descending to the cardiac plexus; *d* 1, placed immediately below the first dorsal sympathetic ganglion; *d* 6, is opposite the sixth; *l* 1, first lumbar ganglion; *cg*, the terminal or coccygeal ganglion.

Preaortic and Visceral Plexuses.—*pp*, pharyngeal, and, lower down, laryngeal plexus; *pl*, posterior pulmonary plexus spreading from the pneumo-gastric on the back of the right bronchus; *ca*, on the aorta, the cardiac plexus, towards which, in addition to the cardiac nerves from the three cervical sympathetic ganglia, other branches are seen descending from the pneumo-gastric and recurrent nerves; *co*, right or posterior, and *co′*, left or anterior coronary plexus; *o*, œsophageal plexus in long meshes on the gullet; *sp*, great splanchnic nerve formed by branches from the fifth, sixth, seventh, eighth, and ninth dorsal ganglia; +, small splanchnic from the ninth and tenth; + +, smallest or third splanchnic from the eleventh: the first and second of these are shown joining the solar plexus, *so*; the third descending to the renal plexus, *re*; connecting branches between the solar plexus and the pneumo-gastric nerves are also represented; *pn′*, above the place where the right pneumo-gastric passes to the lower or posterior surface of the stomach; *pn″*, the left distributed on the anterior or upper surface of the cardiac portion of the organ: from the solar plexus large branches are seen surrounding the arteries of the cœliac axis, and descending to *ms*, the superior mesenteric plexus; opposite to this is an indication of the suprarenal plexus; below *rc* (the renal plexus), the spermatic plexus is also indicated; *ao*, on the front of the aorta, marks the aortic plexus, formed by nerves descending from the solar and superior mesenteric plexuses and from the lumbar ganglia; *mi*, the inferior mesenteric plexus surrounding the corresponding artery; *hy*, hypogastric plexus placed between the common iliac vessels, connected above with the aortic plexus, receiving nerves from the lower lumbar ganglia, and dividing below into the right and left pelvic or inferior hypogastric plexuses; *pl*, the right pelvic plexus; from this the nerves descending are joined by those from the plexus on the superior hemorrhoidal vessels, *mi′*, by sympathetic nerves from the sacral ganglia, and by numerous visceral nerves from the third and fourth sacral spinal nerves, and there are thus formed the rectal, vesical, and other plexuses, which ramify upon the viscera from behind forwards and from below upwards, as towards *ir*, and *v*, the rectum and bladder.

distributed in a great measure to the thoracic aorta, the vertebræ, and ligaments. Several of these branches enter the posterior pulmonary plexus.

The branches furnished by the *lower six or seven ganglia* unite into three cords on each side, which pass down to join plexuses in the abdomen, and are distinguished as the great, the small, and the smallest splanchnic nerve.

THE GREAT SPLANCHNIC NERVE.

This nerve is formed by the union of small cords (roots) given off by the thoracic ganglia from the fifth or sixth to the ninth or tenth inclusive. By careful examination of specimens after immersion in acetic or diluted nitric acid, small filaments may be traced from the splanchnic roots upwards as far as the third ganglion, or even as far as the first (Beck, in the "Philosophical Transactions," Part 2, for 1846).

Gradually augmented by the successive addition of the several roots, the cord descends obliquely inwards over the bodies of the dorsal vertebræ; and, after perforating the crus of the diaphragm at a variable point, termi-

nates in the semilunar ganglion, frequently sending some filaments to the renal plexus and the suprarenal body.

The splanchnic nerve is remarkable from its white colour and firmness, which are owing to the preponderance of the spinal nerve-fibres in its composition.

In the chest the great splanchnic nerve is not unfrequently divided into parts, and forms a plexus with the small splanchnic nerve. Occasionally also a small ganglion (ganglion splanchnicum) is formed on it over the last dorsal vertebra, or the last but one; and when it presents a plexiform arrangement, several small ganglia have been observed on its divisions.

In eight instances out of a large number of bodies, Wrisberg observed a fourth splanchnic nerve (nervus splanchnicus supremus). It is described as formed by offsets from the cardiac nerves, and from the lower cervical, as well as some of the upper thoracic ganglia. ("Observ. Anatom. de Nerv. Viscerum particula prima," p. 25, sect. 3.)

SMALL SPLANCHNIC NERVE.

The small or second splanchnic nerve springs from the tenth or eleventh ganglia, or from the neighbouring part of the cord. It passes along with the preceding nerve, or separately through the diaphragm, and ends in the cœliac plexus. In the chest this nerve often communicates with the large splanchnic nerve; and in some instances it furnishes filaments to the renal plexus, especially if the lowest splanchnic nerve is very small or wanting.

SMALLEST SPLANCHNIC NERVE.

This nerve (nerv. renalis posterior—Walter) arises from one of the lowest thoracic ganglia, and communicates sometimes with the nerve last described. After piercing the diaphragm, it ends in the renal plexus, and in the inferior part of the cœliac plexus.

LUMBAR PART OF THE GANGLIATED CORD.

In the lumbar region the two gangliated cords approach one another more nearly than in the thorax. They are placed before the bodies of the vertebræ, each lying along the inner margin of the psoas muscle; and that of the right side is partly covered by the vena cava.

The ganglia are small, and of an oval shape. They are commonly four in number, but occasionally, when their number is diminished, they are of larger size.

Connection with spinal nerves.—In consequence of the greater distance at which the lumbar ganglia are placed from the intervertebral foramina, the branches of connection with the spinal nerves are longer than in other parts of the gangliated cord. There are generally two connecting branches for each ganglion, but the number is not so uniform as it is in the chest; nor are those belonging to any one ganglion connected always with the same spinal nerve. The connecting branches accompany the lumbar arteries, and, as they cross the bodies of the vertebræ, are covered by the fibrous bands which give origin to the larger psoas muscle.

Branches.—The branches of these ganglia are uncertain in their number. Some join a plexus on the aorta; others descending go to form the hypogastric plexus. Several filaments are distributed to the vertebræ and the ligaments connecting them.

SACRAL PART OF THE GANGLIATED CORD.

Over the sacrum the gangliated cord of the sympathetic nerve is much

diminished in size, and gives but few branches to the viscera. Its position on the front of the sacrum is along the inner side of the anterior sacral foramina; and, like the two series of those foramina, the two cords approach one another in their progress downwards. The upper end of each is connected with the last lumbar ganglion by a single or a double interganglionic cord; and at the lower end, they are connected by means of a loop with a single median ganglion, *ganglion impar*, placed on the fore part of the coccyx. The sacral ganglia are usually five in number; but the variation both in size and number is more marked in these than in the thoracic or lumbar ganglia.

Connection with spinal nerves.—From the proximity of the sacral ganglia to the spinal nerves at their emergence from the foramina, the communicating branches are very short: there are usually two for each ganglion, and these are in some cases connected with different sacral nerves. The coccygeal nerve communicates with the last sacral, or the coccygeal ganglion.

Branches.—The branches proceeding from the sacral ganglia are much smaller than those from other ganglia of the cord. They are for the most part expended on the front of the sacrum, and join the corresponding branches from the opposite side. Some filaments from one or two of the first ganglia enter the hypogastric plexus, while others go to form a plexus on the middle sacral artery. From the loop connecting the two cords on which the coccygeal ganglion is formed, filaments are given to the coccyx and the ligaments about it, and to the coccygeal gland.

COCCYGEAL GLAND.

Under this name has been described by Luschka a minute structure, which has since received the attention of a number of writers. It is usually, according to Luschka, of the size of a lentil, and sometimes as large as a small pea; its colour is reddish grey; its surface lobulated; and it occupies a hollow at the tip of the coccyx, between the tendons attached to that part. It receives terminal twigs of the middle sacral artery and minute filaments from the ganglion impar. It consists of an aggregation of grains or lobules, which in some instances remain separate one from another. These lobules are principally composed of thick-walled cavities of vesicular and tubular appearance, described by Luschka and subsequent writers as closed follicles filled with cellular contents, but recently demonstrated by Julius Arnold to be clumps of dilated and tortuous small arteries, with thickened muscular and epithelial coats. Nerve-cells are found scattered in the stroma of the organ.

The coccygeal gland is a structure evidently of a similar nature to the ganglion intercaroticum, the principal differences apparently being, that the glomeruli of the ganglion intercaroticum are produced principally by the convolution and ramification of arterial twigs, while in the coccygeal gland there is dilatation of the branches and thickening of their walls; and that the nervous element is more developed in the intercarotid ganglion than in the coccygeal gland. Arnold, with Luschka, appears inclined to consider both structures as allied in nature to the suprarenal capsules. According to Arnold, there is always a number of small grape-like appendages on the coccygeal part of the middle sacral artery, microscopic in size, but similar in nature to the lobules of which the coccygeal gland is composed. (Luschka, "Der Hirnanhang und die Steissdruse des Menschen." Berlin, 1860. Also "Anat. d. Mensch.," vol. ii., part 2, p. 187. Julius Arnold in Virchow's "Archiv," March, 1865.)

B. THE GREAT PLEXUSES OF THE SYMPATHETIC.

Under this head may be included certain large plexuses of nerves placed further forwards in the visceral cavity than the gangliated cords, and furnishing branches to the viscera. The principal of these plexuses are the cardiac, the solar, and the hypogastric with the pelvic plexuses prolonged from it. They are composed of assemblages of nerves, or of nerves and ganglia, and from them smaller plexuses are derived.

CARDIAC PLEXUS.

This plexus receives the cardiac branches of the cervical ganglia and those of the pneumo-gastric nerves, and from it proceed the nerves which supply the heart, besides some offsets which contribute to the nervous supply of the lungs. It lies upon the aorta and pulmonary artery, where these vessels are in contact, and in its network are distinguished two parts, the superficial and the deep cardiac plexuses, the deep plexus being seen behind the vessels, and the superficial more in front, but both being closely connected. The branches pass from these plexuses chiefly forward in two bundles, accompanying the coronary arteries.

SUPERFICIAL CARDIAC PLEXUS.

The superficial cardiac plexus lies in the concavity of the arch of the aorta, in front of the right branch of the pulmonary artery. In it the superficial or first cardiac nerve of the sympathetic of the left side terminates, either wholly or in part, together with the lower cardiac branch of the left pneumo-gastric nerve, and in some cases also that of the right side. In the superficial plexus a small ganglion, the *ganglion of Wrisberg*, is frequently found at the point of union of the nerves. Besides ending in the anterior coronary plexus, the superficial cardiac furnishes laterally filaments along the pulmonary artery to the anterior pulmonary plexus of the left side.

DEEP CARDIAC PLEXUS.

The deep cardiac plexus, much larger than the superficial one, is placed behind the arch of the aorta, between it and the end of the trachea, and above the point of division of the pulmonary artery.

This plexus receives all the cardiac branches of the cervical ganglia of the sympathetic nerve, except the first or superficial cardiac nerve of the left side. It likewise receives the cardiac nerves furnished by the vagus and by the recurrent laryngeal branch of that nerve, with the exception of the left lower cardiac nerve.

Of the branches from the *right side* of the plexus, the greater number descend in front of the right pulmonary artery, and join branches from the superficial part in the formation of the anterior coronary plexus, while the rest, passing behind the right pulmonary artery, are distributed to the right auricle of the heart, and a few filaments are continued into the posterior coronary plexus.

On the *left side*, a few branches pass forwards by the side of the ductus arteriosus to join the superficial cardiac plexus; but the great majority end in the posterior coronary plexus.

The deep cardiac plexus sends filaments to the anterior pulmonary plexus on each side.

Coronary Plexuses.—The *anterior coronary plexus*, formed at first from the fibres of the superficial cardiac plexus, passes forwards between the aorta and pulmonary artery, and, having received an accession of fibres from the deep cardiac plexus, follows the course of the left or anterior coronary artery.

The *posterior coronary plexus*, derived chiefly from the left part of the deep cardiac plexus, but joined by nerves from the right portion of that plexus, surrounding the branches of the right coronary artery accompany them to the back of the heart.

Nervous filaments ramify in great number under the lining membrane of the heart. They are not so easily distinguished in man as in some animals. In the heart of the calf or lamb they are distinctly seen without dissection, running in lines which cross obliquely the muscular fibres. Remak was the first to observe that these branches are furnished with small ganglia, both on the surface and in the muscular substance. (Müller's "Archiv," 1844.)

SOLAR OR EPIGASTRIC PLEXUS.

The solar or epigastric plexus, which is the largest of the prevertebral centres, is placed at the upper part of the abdomen, behind the stomach, and in front of the aorta and the pillars of the diaphragm. Surrounding the origin of the cœliac axis and the upper mesenteric artery, it occupies the interval between the suprarenal bodies, and extends downwards as far as the pancreas. The plexus consists of nervous cords, with several ganglia of various sizes connected with them. The large splanchnic nerves of both sides, and some branches of the pneumo-gastric, terminate in it. The branches given off from it are very numerous, and accompany the arteries to the principal viscera of the abdomen, constituting so many secondary plexuses on the vessels. Thus diaphragmatic, cœliac, renal, mesenteric, and other plexuses are recognised, which follow the corresponding arteries.

Semilunar ganglia.—The solar plexus contains, as already mentioned, several ganglia ; and by the presence of these bodies, and their size, it is distinguished from the other prevertebral plexuses. The two principal ganglionic masses, named *semilunar*, though they have often little of the form the name implies, occupy the upper and outer part of the plexus, one on each side, and are placed close to the suprarenal bodies by the side of the cœliac and the superior mesenteric arteries. At the upper end, which is expanded, each ganglion receives the great splanchnic nerve.

Diaphragmatic Plexus.—The nerves (inferior diaphragmatic) composing this plexus are derived from the upper part of the semilunar ganglion, and are larger on the right than on the left side. Accompanying the arteries along the lower surface of the diaphragm, the nerves sink into the substance of the muscle. They furnish some filaments to the suprarenal body, and join with the spinal phrenic nerves.

At the right side, on the under surface of the diaphragm, and near the suprarenal body, there is a small ganglion, *ganglion diaphragmaticum*, which marks the junction between the phrenic nerves of the spinal and sympathetic systems. From this small ganglion filaments are distributed to the vena cava, the suprarenal body, and the hepatic plexus. On the left side the ganglion is wanting, but some filaments are prolonged to the hepatic plexus.

Suprarenal Plexus.—The suprarenal nerves issue from the solar plexus and the outer part of the semilunar ganglion, a few filaments being added from the diaphragmatic nerve. They are short, but numerous in comparison with the size of the body which they supply : they enter the upper and inner parts of the suprarenal capsule. These nerves are continuous below with the renal plexus. The plexus is joined by branches from one of the splanchnic nerves, and presents a ganglion (*gangl. splanchnico-supra-renale*), where it is connected with those branches. The plexus and ganglion are smaller on the left than on the right side.

Fig. 455.

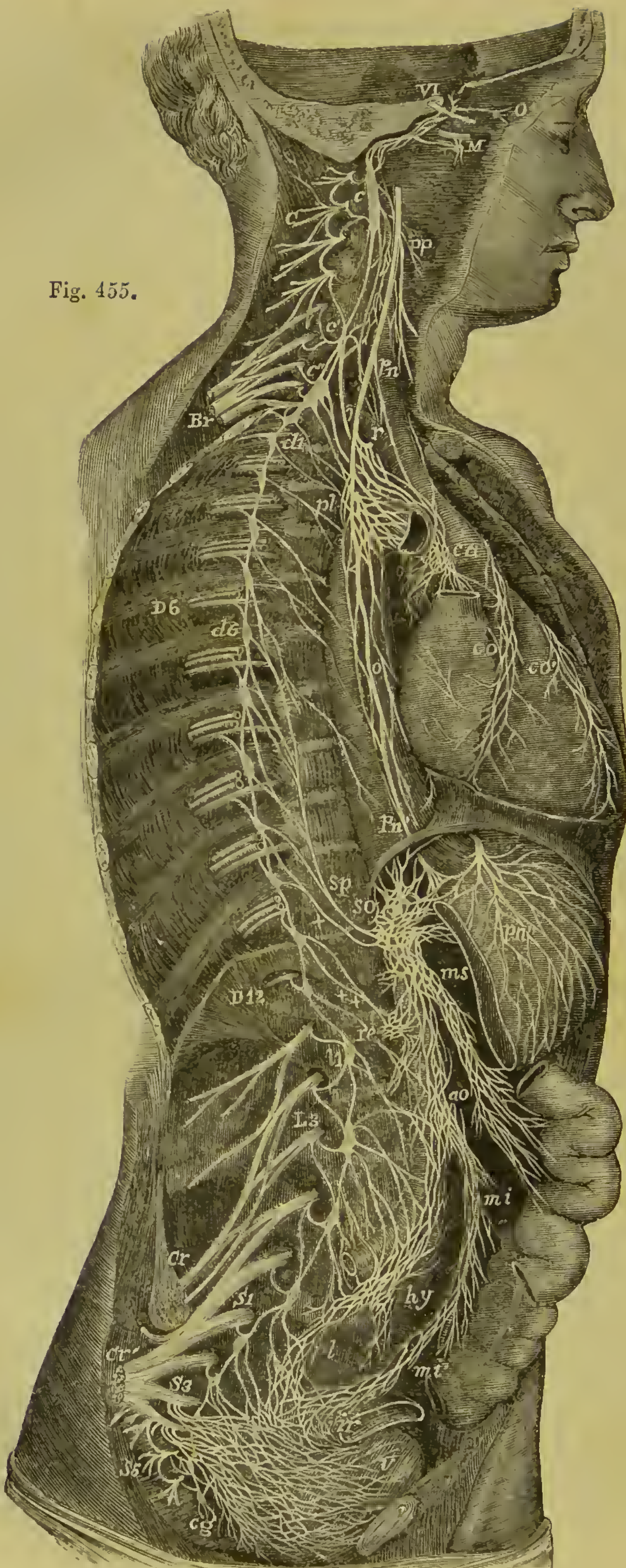

VI
O
M
c
pp
c'
pn
Br
d1
r
pl
ca
D6
d6
co
co'
o
pn'
sp
so
pn'
ms
D12
re
L1
ao
L3
mi
cr
S1
hy
cr'
l
mr
S3
S5
v
cg

Fig. 455.—Diagrammatic View of the Sympathetic Cord of the Right Side, with its Principal Ganglia, Plexuses, and Nerves.

This figure is repeated in illustration of the sympathetic nerves in the lower half of the body.

c, superior cervical ganglion ; *c'*, second or middle ; *c''*, inferior : from each of these ganglia cardiac nerves (deep on this side) are seen descending to the cardiac plexus ; *d* 1, placed immediately below the first dorsal sympathetic ganglion ; *d* 6, is opposite the sixth ; *l* 1, first lumbar ganglion ; *cg*, the terminal or coccygeal ganglion ; *pp*, pharyngeal, and, lower down, laryngeal plexus ; *pl*, posterior pulmonary plexus spreading from the pneumo-gastric on the back of the right bronchus ; *ca*, on the aorta, the cardiac plexus, towards which, in addition to the cardiac nerves from the three cervical sympathetic ganglia, other branches are seen descending from the pneumogastric and recurrent nerves ; *co*, right or posterior, and *co'*, left or anterior coronary plexus ; o, œsophageal plexus in long meshes on the gullet ; *sp*, great splanchnic nerve formed by branches from the fifth, sixth, seventh, eighth, and ninth dorsal ganglia ; +, small splanchnic from the ninth and tenth ; + +, smallest or third splanchnic from the eleventh : the first and second of these are shown joining the solar plexus, *so* ; the third descending to the renal plexus, *re* ; connecting branches between the solar plexus and the pneumo-gastric nerves are also represented ; *pn'*, above the place where the right pneumo-gastric passes to the lower or posterior surface of the stomach ; *pn''*, the left distributed on the anterior or upper surface of the cardiac portion of the organ : from the solar plexus large branches are seen surrounding the arteries of the cœliac axis, and descending to *ms*, the superior mesenteric plexus ; opposite to this is an indication of the suprarenal plexus ; below *re* (the renal plexus), the spermatic plexus is also indicated ; *ao*, on the front of the aorta, marks the aortic plexus, formed by nerves descending from the solar and superior mesenteric plexuses and from the lumbar ganglia ; *mi*, the inferior mesenteric plexus surrounding the corresponding artery ; *hy*, hypogastric plexus placed between the common iliac vessels, connected above with the aortic plexus, receiving nerves from the lower lumbar ganglia, and dividing below into the right and left pelvic or inferior hypogastric plexuses ; *pl*, the right pelvic plexus ; from this the nerves descending are joined by those from the plexus on the superior hemorrhoidal vessel, *mi'*, by sympathetic nerves from the sacral ganglia, and by numerous visceral nerves from the third and fourth sacral spinal nerves, and there are thus formed the rectal, vesical, and other plexuses, which ramify upon the viscera from behind forwards and from below upwards, as towards *ir*, and *v*, the rectum and bladder.

Renal Plexus.—The nerves forming the renal plexus, fifteen or twenty in number, emanate for the most part from the outer part of the semilunar ganglion ; but some are added from the solar plexus and the aortic plexus. Moreover, filaments from the smallest splanchnic nerve, and occasionally from the other splanchnic nerves, terminate in the renal plexus. In their course along the renal artery, ganglia of different sizes are formed on these nerves. Lastly, dividing with the branching of the vessel, the nerves follow the renal arteries into the substance of the kidney. On the right side some filaments are furnished to the vena cava, behind which the plexus passes with the renal artery ; and others go to form the spermatic plexus.

Spermatic Plexus.—This small plexus commences in the renal, but receives in its course along the spermatic artery an accession from the aortic plexus. Continuing downwards to the testis, the spermatic nerves are connected with others which accompany the vas deferens and its artery from the pelvis.

In the female, the plexus, like the artery, is distributed to the ovary and the uterus.

Cœliac Plexus.—This plexus is of large size, and is derived from the fore part of the great epigastric plexus. It surrounds the cœliac axis in a kind of membranous sheath, and subdivides, with the artery, into coronary, hepatic, and splenic plexuses, the branches of which form communications corresponding with the arches of arterial anastomosis. The plexus receives offsets from one or more of the splanchnic nerves, and on the left side a branch from the pneumo-gastric nerve is continued into it. (Swan.)

The *coronary plexus* is placed with its artery along the small curvature of the stomach, and unites with the nerves which accompany the pyloric artery, as well as with branches of the pneumo-gastric nerves. The nerves of this plexus enter the coats of the stomach, after running a short distance beneath the peritoneum.

The *hepatic plexus*, the largest of the three divisions of the cœliac plexus, ascends with the hepatic vessels and the bile-duct, and, entering the substance of the liver,

ramifies on the branches of the vena portæ and the hepatic artery. Offsets from the left pneumo-gastric and diaphragmatic nerves join the hepatic plexus at the left side of the vessels. From this plexus filaments are furnished to the right supra-renal plexus, as well as other secondary plexuses which follow the branches of the hepatic artery. Thus there is a *cystic* plexus to the gall-bladder; and there are *pyloric*, *gastro-epiploic*, and *gastro-duodenal* plexuses, which unite with coronary, splenic, and mesenteric nerves.

The *splenic plexus*, continued on the splenic artery and its branches into the substance of the spleen, is reinforced at its beginning by branches from the left semilunar ganglion, and by a filament from the right vagus nerve. It furnishes the *left gastro-epiploic* and *pancreatic* plexuses, which course along the corresponding branches of the splenic artery, and, like the vessels, are distributed to the stomach and pancreas.

Superior Mesenteric Plexus.—The plexus accompanying the superior mesenteric artery, whiter in colour and firmer than either of the preceding offsets of the solar plexus, envelopes the artery in a membraniform sheath, and receives a prolongation from the junction of the right pneumo-gastric nerve with the cœliac plexus. Near the root of the artery, ganglionic masses (gangl. meseraica) occur in connection with the nerves of this plexus.

The offsets of the plexus are in name and distribution the same as the vessels. In their progress to the intestine some of the nerves quit the arteries which first supported them, and are directed forwards in the intervals between the vessels. As they proceed, they divide, and unite with lateral branches, like the arteries, but without the same regularity; they finally pass upon the intestine along the line of attachment of the mesentery.

THE AORTIC PLEXUS.

The aortic or intermesenteric plexus, placed along the abdominal aorta, and occupying the interval between the origin of the superior and inferior mesenteric arteries, consists, for the most part, of two lateral portions, connected with the semilunar ganglia and renal plexuses, which are extended on the sides of the aorta, and which meet in several larger communicating branches over the middle of that vessel. It is joined by branches from some of the lumbar ganglia, and presents not unfrequently one or more distinct ganglionic enlargements towards its centre.

The aortic plexus furnishes the inferior mesenteric plexus and part of the spermatic, gives some filaments to the lower vena cava, and ends below in the hypogastric plexus.

Inferior Mesenteric Plexus.—This plexus is derived principally from the left lateral part of the aortic plexus, and closely surrounds with a network the inferior mesenteric artery. It distributes nerves to the left or descending part and the sigmoid flexure of the colon, and assists in supplying the rectum. The nerves of this plexus, like those of the superior mesenteric plexus, are firm in texture, and of a whitish colour.

The highest branches (those on the left colic artery) are connected with the last branches (middle colic) of the superior mesenteric plexus, while others in the pelvis unite with offsets derived from the pelvic plexus.

HYPOGASTRIC PLEXUS.

The hypogastric plexus, the assemblage of nerves destined for the supply of the viscera of the pelvis, lies invested in a sheath of dense connective tissue, in the interval between the two common iliac arteries. It is formed by eight or ten nerves on each side, which descend from the aortic plexus, receiving considerable branches from the lumbar ganglia, and, after crossing the common iliac artery, interlace in the form of a flat plexiform mass placed in front of the lowest lumbar vertebra. The plexus contains no

distinct ganglia. At the lower end it divides into two parts, which are directed forwards, one to each side of the pelvic viscera, and form the pelvic plexuses.

PELVIC PLEXUS.

The pelvic or inferior hypogastric plexuses, one on each side, are placed in the lower part of the pelvic cavity by the side of the rectum, and of the vagina in the female. The nerves, prolonged from the hypogastric plexus, enter into repeated communications as they descend, and form at the points of connection small knots, which contain a little ganglionic matter. After descending some way, they become united with branches of the spinal nerves, as well as with a few offsets of the sacral ganglia, and the union of all constitutes the pelvic plexus. The spinal branches, which enter into the plexus, are furnished from the third and fourth sacral nerves, especially the third; and filaments are likewise added from the first and second sacral nerves. Small ganglia are formed at the places of union of the spinal nerves, as well as elsewhere in the plexus (plexus gangliosus—Tiedemann).

From the plexus so constituted numerous nerves are distributed to the pelvic viscera. They correspond with the branches of the internal iliac artery, and vary with the sex; thus, besides hæmorrhoidal and vesical nerves, which are common to both sexes, there are nerves special to each:—namely, in the male, for the prostate, vesicula seminalis, and vas deferens; in the female, for the vagina, uterus, ovary, and Fallopian tube.

The nerves distributed to the urinary bladder and the vagina contain a larger proportion of spinal nerves than those furnished to the other pelvic viscera.

Inferior Hæmorrhoidal Nerves.—These slender nerves proceed from the back part of the pelvic plexus. They join with the nerves (superior hæmorrhoidal) which descend with the inferior mesenteric artery, and penetrate the coats of the rectum.

Vesical Plexus.—The nerves of the urinary bladder are very numerous. They are directed from the anterior part of the pelvic plexus to the side and lower part of the bladder. At first, these nerves accompany the vesical blood-vessels, but afterwards they leave the vessels, and subdivide into minute branches before perforating the muscular coat of the organ. Secondary plexuses are given in the male to the vas deferens and the vesicula seminalis.

The *nerves of the vas deferens* ramify round that tube, and communicate in the spermatic cord with the nerves of the spermatic plexus. Those furnished to the *vesicula seminalis* form an interlacement on the vesicula, and some branches penetrate its substance. Other filaments from the prostatic nerves reach the same structure.

Prostatic Plexus.—The nerves of this plexus are of considerable size, and pass onwards between the prostate gland and the levator ani. Some are furnished to the prostate and to the vesicula seminalis; and the plexus is then continued forwards to supply the erectile substance of the penis, where its nerves are named "cavernous."

Cavernous nerves of the penis.—These are very slender, and difficult to dissect. Continuing from the prostatic plexus they pass onwards, beneath the arch of the pubes, and through the muscular structure connected with the membranous part of the urethra, to the dorsum of the penis. At the anterior margin of the levator ani muscle the cavernous nerves are joined

by some short filaments from the pudic nerve. After distributing twigs to the fore part of the prostate, these nerves divide into branches for the erectile substance of the penis, as follows :—

Small cavernous nerves (Müller), which perforate the fibrous covering of the corpus cavernosum near the root of the penis, and end in the erectile substance.

The *large cavernous nerve*, which extends forward on the dorsum of the penis, and dividing, gives filaments that penetrate the corpus cavernosum, and pass with or near the cavernous artery (art. profunda penis). As it continues onwards, this nerve joins with the dorsal branch of the pudic nerve about the middle of the penis, and is distributed to the corpus cavernosum. Branches from the foregoing nerves reach the corpus spongiosum urethræ. (Müller, "Ueber die organischen Nerven der erectilen männlichen Geschlechtsorgane," &c. Berlin, 1836.)

Nerves of the Ovary.—The ovary is supplied chiefly from the plexus prolonged on the ovarian artery from the abdomen ; but it receives another offset from the uterine nerves.

Vaginal Plexus.—The nerves furnished to the vagina leave the lower part of the pelvic plexus—that part with which the spinal nerves are more particularly combined. They are distributed to the vagina without previously entering into a plexiform arrangement ; and they end in the erectile tissue on the lower and anterior part, and in the mucous membrane.

Nerves of the Uterus.—These nerves are given more immediately from the lateral fasciculus prolonged to the pelvic plexus from the hypogastric plexus, above the point of connection with the sacral nerves. Separating opposite the neck of the uterus, they are directed upwards with the blood-vessels along the side of this organ, between the layers of its broad ligament. Some very slender filaments form round the arteries a plexus, in which minute ganglia are found scattered at intervals, and these nerves continue their course in the substance of the organ in connection with the blood-vessels. But the larger part of the nerves soon leave the vessels ; and after dividing repeatedly, without communicating with each other and without forming any gangliform enlargements, sink into the substance of the uterus, penetrating for the most part its neck and the lower part of its body. One branch, continued directly from the common hypogastric plexus, reaches the body of the uterus above the rest ; and a nerve from the same source ascends to the Fallopian tube. Lastly, the fundus of the uterus often receives a branch from the ovarian nerve. (Fr. Tiedemann, Tab. Nerv. Uteri, Heidelberg, 1822 ; Robert Lee, in Phil. Trans., 1841, 1842, 1846, and 1849 ; and Snow Beck, in Phil. Trans., 1846, part ii.)

The *nerves of the gravid uterus* have been frequently investigated, with a view to discover if they become enlarged along with the increase in size of the organ. It is ascertained that the increase which takes place is confined, for the most part, to thickening of the fibrous envelopes of the nerves ; but it appears also, from the researches of Kilian, that fibres furnished with a medullary sheath, which in the unimpregnated state of the uterus lose that sheath as they proceed to their distribution, in the impregnated condition of the uterus continue to be surrounded with it as they run between the muscular fibres. (Farre, in Supplement of Cyclopædia of Anat. and Phys., "Uterus and Appendages.")